WORLD ANIMAL REVIEW

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A QUARTERLY JOURNAL DEVOTED TO WORLD DEVELOPMENTS IN ANIMAL PRODUCTION, ANIMAL HEALTH AND ANIMAL PRODUCTS

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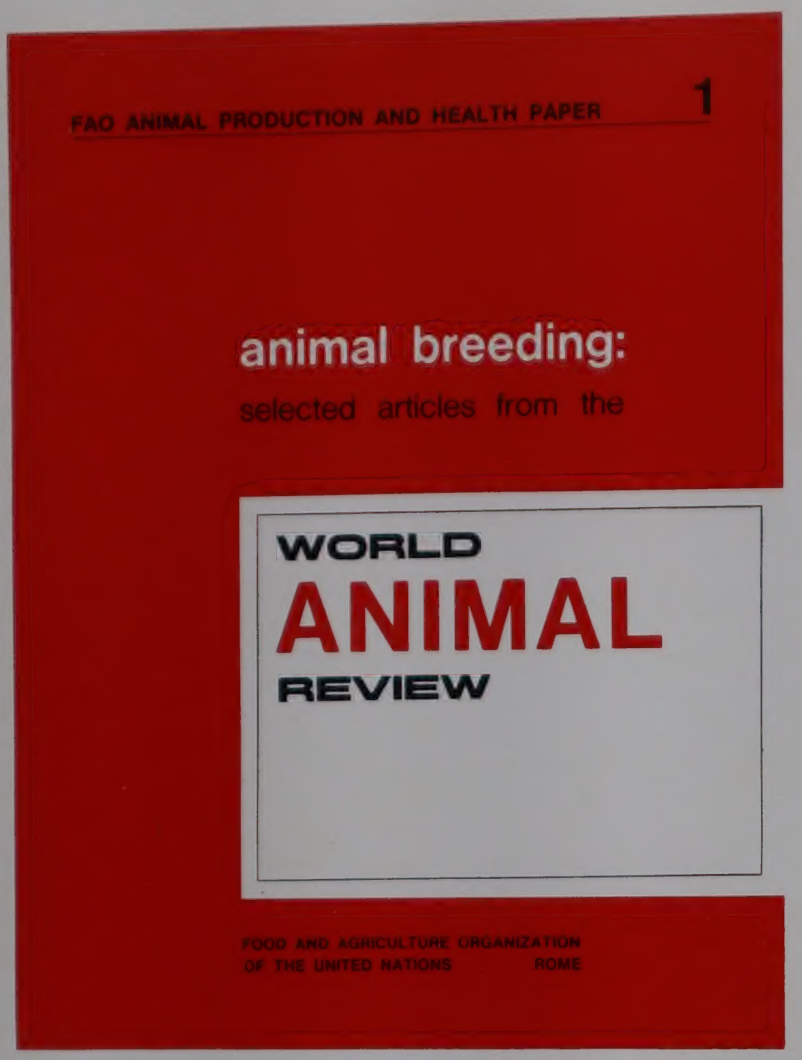

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FAO Animal Production and Health Paper No. 1 is a volume containing articles on animal breeding published in the first twenty issues of the *World Animal Review*. It presents the experience and the results of the work of animal breeders and geneticists from sixteen countries. Although the main focus of the articles is on animal breeding in developing areas of the world, information from developed countries is also included. The publication is designed to provide a ready and easy reference to those concerned with the improvement of milk and meat production, particularly in the warmer areas of the world.

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Table of contents

		Page
Introduction		iii
GENERAL		
G.R. Duncanson	The Kenya National Artificial Insemination Service (16)	1
A. Bane and C.A. Hultnäs	Artificial insemination of cattle in developing countries (9)	6
K.N. Bedirian, E.B. Burnside, H. Kanagawa and J. Wilton	The commercial application of embryo transfer in domestic animals (13)	12
U.B. Lindström	Utilizing animal gene resources (18)	17
R.L. Willham	New facets of animal breeding research in the United States (18)	25
DAIRY CATTLE		
U.B. Lindström	Milk recording in developing countries (19)	31
I.L. Mason	Maintaining crossbred populations of dairy cattle in the tropics (11)	40
V. Buvanendran and P. Mahadevan	Crossbreeding for milk production in Sri Lanka (15)	48
R.H. Hayman	The development of the Australian Milking Zebu (11)	55
K. Meyn and J.V. Wilkins	Breeding for milk in Kenya, with particular reference to the Sahiwal Stud (11)	60
K.E. Wellington and P. Mahadevan	Development of the Jamaica Hope breed of dairy cattle (15)	67
R.H. Ansell	Maintaining European dairy cattle in the Near East (20)	73
Ove Madsen	Red Danish cattle in the tropics (19)	80
Lucia Pearson de Vaccaro	Dairy cattle breeding in tropical South America (12)	86
BEEF CATTLE		
H.G. Turner	The tropical adaptation of beef cattle (13)	92
B. Vissac	Using large muscular breeds to improve world beef production (19)	98
J.C.M. Trail and T.W. Rennie	Botswana: Performance testing of beef cattle (14)	105
M.J. Creek	The Kenya feedlot project (3)	110
OTHER		
Helen Newton Turner	Some aspects of sheep breeding in the tropics (10)	115
Michael Welham	Crossbreeding sheep for milk and meat in a Mediterranean environment (19)	122
Saúl Fernández-Baca	Alpaca raising in the High Andes (14)	126

Note: The number in brackets refers to the issue of *World Animal Review* in which the article originally appeared.

WORLD ANIMAL REVIEW

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Water buffalo research: possible future trends
P. MAHADEVAN 2

Utilizing breed differences in growth of cattle in the tropics
J.E. FRISCH and J.E. VERCOE 8

Factors affecting the location of slaughterhouses in developing countries
H.J. MITTENDORF 13

Use of non-milk proteins in milk substitutes for calves
I.J.F. STOBO and J.H.B. ROY 18

Feeding potential of pineapple waste for cattle
Z.O. MÜLLER 25

Dairy development in India — Part II
MOGENS JUL 30

Vesicular diseases of swine
JOHN H. GRAVES 37

News and notes 42

New books 46

WORLD ANIMAL REVIEW is a quarterly journal reviewing developments in animal production, animal health and animal products, with particular reference to these spheres in Asia, Africa and Latin America. It is published by the Food and Agriculture Organization of the United Nations. FAO was founded in Quebec, Canada, in October 1945, when the Member Nations agreed to work together to secure a lasting peace through freedom from want. The membership of FAO numbers 144 nations.

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COVER: Swamp buffaloes being used as draught animals in Thailand

Photograph by Punnahitananda Boonserm (FAO)

Water buffalo research - possible future trends

P. Mahadevan

The suggestion has been put forward from time to time by various agencies and governments concerned with international agricultural development that an institute be established which would serve as a world centre for the improvement of the water buffalo.

The Technical Advisory Committee (TAC) to the Consultative Group on International Agricultural Research (CGIAR) considered the proposals for the establishment of an international buffalo research centre under the aegis of the CGIAR and decided to sponsor an expert consultation on buffalo research, held in Singapore in March 1976. The basic recommendation of the consultation was the establishment of a cooperative research network of national centres with a small coordinating unit suitably sited to effect adequate intercommunication and monitoring. Subsequently the TAC arranged for the services of a consultant to visit programmes in the Asian and Near East regions to assess current research on the water buffalo and the talent available in this field; to appraise the resources devoted to the subject in the various countries; to identify the problems needing investigation, particularly those which require international cooperation; and to formulate proposals for international support to an intercountry cooperative research programme on the water buffalo. The consultant was also required to assess different possible organizational alternatives for such an international collaborative research effort. The domestic water buffalo population of the world, numbering over 130 million, is shown in Table 1 according to countries and regions. India has about half the world's buffaloes; China comes second with 30 million, and Pakistan third with 10 million.

TABLE 1. **World distribution of buffaloes**

	(Thousand head)
ASIA	
Burma	1 883
China	30 110
India	60 767
Indonesia	2 823
Lao	1 072
Malaysia	285
Nepal	3 860
Philippines	5 050
Sri Lanka	736
Thailand	5 784
Viet Nam	2 330
Others	2 238
OCEANIA	
Australia	200
EUROPE	
Bulgaria	68
Italy	81
Romania	206
Others	78
NEAR EAST	
Egypt	2 280
Iran	130
Iraq	332
Pakistan	10 563
Turkey	1 022
U.S.S.R.	427
SOUTH AMERICA	166
CARIBBEAN	7
WORLD TOTAL	132 498

ECONOMIC IMPORTANCE

In some countries (notably the Philippines and Thailand) there are substantially more buffaloes than cattle, and they are a major source of farm power and a good source of meat.

In other countries, although cattle numbers are far in excess of buffalo numbers, buffaloes play a much more important role in the national economy. Two outstanding examples are India and Pakistan.

In India, although the proportion of buffaloes to cattle is 1:3, the buffalo contributes 55 percent of the milk produced in the country and 60 percent of the meat obtained from cattle and buffaloes. Furthermore, almost 95 percent of the milk handled by the dairy plants supplying milk to the cities comes from buffaloes. It is also relevant to note that the overall buffalo population of India has increased by some 13 percent during the last decade, compared with about 2 percent in the case of cattle.

In Pakistan about 70 percent of the milk produced comes from buffaloes although they are outnumbered by cattle by some 30 percent. Their importance to the national economy is further evidenced by a 7 percent increase in the buffalo population from 1972 to 1976, as compared with a 1.5 percent increase in cattle numbers. The annual value of the products contributed by buffaloes is estimated to be

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greater than the combined output of cattle, sheep and goats.

In Egypt, where buffalo and cattle numbers are almost equal, buffaloes contribute about 65 percent of the 2 million tons of milk produced annually in that country.

Nevertheless, despite the important role that the buffalo plays in the economy of many countries, the farming techniques utilized to exploit this resource at the small farm level have, for the most part, remained unchanged for centuries. This applies to both the swamp buffaloes of southeast Asia, which are primarily used for draught and also for meat, and the river buffaloes found in other parts of the world, where they serve as a major source of milk and meat and are also necessary as draught animals.

CURRENT NATIONAL RESEARCH

The assessment of national research on the water buffalo clearly showed that the major constraints against improvements in buffalo productivity in all countries are due to lack of relevant research, inadequate testing and demonstration of research results on a field scale, and lack of effective extension effort, combined with the generally low level of development of the countries concerned. The lack of relevant research is discussed below.

Nutrition research. Most of the nutrition research that has been hitherto undertaken on buffaloes has been on feeding systems involving large quantities of high-quality forages and concentrates; but there is little scope for the application of the results of such research outside the experiment station. As a consequence, most research stations, instead of being far ahead of the farmers as is commonly assumed, are simply unable to provide the kind of technology needed.

For instance, the annual availability of concentrate feeds for cattle and buffaloes in most countries is low. In India, for example, it is optimistically estimated to amount to some 20 million tons; even at this level of availability, each animal gets on an average only about 250 g per day. Concentrate utilization based on the results of research that are dependent on high levels of concentrate feeding is therefore meaningless; a more important problem would be to decide how to allocate this scarce resource to maximize total production.

The availability of high-quality forage is also limited in all countries. In India forage is grown on about 7 million hectares annually, an area which has not increased over the past 30 years and will probably not increase much in the future. On average 30 animals share the forage produced on a hectare of land, each animal getting some 2 to 3 kg per day. Thus the majority of the animals outside the experiment station cannot be supported on large quantities of cultivated high-quality forages. Such forages can only be regarded as a vitally important supplement and, although every effort to increase their per hectare yield and quality is justified, they do not constitute the most important problem in nutrition research.

Other deficiencies in past nutritional research include the lack of standardized procedures for intake and digestibility studies on tropical and subtropical feeds, the lack of recognition of the effects of supplementation and level of intake on digestibility, and the non-availability of standard samples of known intake and digestibility. One of the principal reasons for the continued existence of these deficiencies is the narrow focus of individual research, with little or no involvement of the individual scientist in the work of others.

Swamp × Murrah crossbred buffalo castrate used for work at Livestock Research Institute near Nanning, China. There is a need to determine the "best" breeds (for milk, meat, work) for use in crossbreeding and upgrading programmes.

Photo: W. Ross Cockrill

Research on reproduction and AI. Low reproductive efficiency is accepted as a universal problem in buffaloes, but the reasons underlying the parameters of poor reproductive performance have not yet been fully elucidated. Estimates have been made of the heritabilities of some of the components of reproductive efficiency in buffaloes, e.g., age at first calving, length of the service period, and length of the calving interval. The possible relationships between these components and various environmental conditions have been investigated; poor nutrition, improper management and inadequate schemes of sexual health

control have been incriminated as contributory factors to poor reproductive performance. The incidence and duration of post-partum anoestrus and the occurrence of silent heat have been variously estimated by different investigators. But no technology usable at the small farm level has yet been generated for improving the reproductive efficiency of buffaloes.

Research on AI has made possible the use in villages of liquid semen collected from buffalo males in institutional herds. However, fertility levels continue to be dependent on the accuracy of detecting oestrus in the females. The problem of reproductive efficiency has been further complicated by efforts to use frozen buffalo semen, thus highlighting the need for much more systematic research on semen technology. In most institutions the approach hitherto adopted has been to test various semen diluents on a "hit-and-miss" basis rather than to seek an understanding of the basic characteristics of buffalo semen. The end results are that the claims of success in one institution are often negated by another institution less than 200 km away, and the reproductive pattern of buffaloes continues to be a confusing one.

Breeding research. All national institutions appear to be showing a growing interest in the genetics of milk and meat production in the water buffalo, but the research undertaken in this area continues to be highly fragmented. The principal focus of most investigations is to establish various phenotypic and genetic parameters through analyses of available herd data, rather than to answer specific field-oriented questions that could lead to practical improvements in milk, meat and draught capabilities. This problem is related to the way in which the data are generated. Research workers seem to look about for whatever records are available and then decide on some things that might be done with them; little attention is devoted to establishing the hypotheses that require testing and then to generating the required data.

In all livestock species except buffaloes, the "best" breeds are continually being used for improving the others through crossbreeding and upgrading programmes. In buffaloes on the other hand, although considerable information is available on the breeds of northern India and Pakistan and on the swamp breeds in relation to them, it is not known how the Murrah or the Nili-Ravi, for example, compares in milk yield and growth rate with the buffaloes of Europe and the Near East. Likewise, although several institutions have recognized the inadequacies of progeny testing dairy sires in single herds and have moved on to a combination of testing in an institutional herd plus testing at the village level, the infrastructure and methodology for such combined testing have still not been adequately developed. This applies also to performance testing for meat and work.

TABLE 2. **Net annual food calorie balance in relation to feeding regime (buffaloes)**

Feeding regime	Annual milk production	Input	Output	Balance
	Kg	..... *Mcal*		
Cultivated forage from 1/6 ha land plus 600 kg concentrate feed/year	2 000	[1] 5 200	2 200	—3 000
Alkali-treated straw (8-10 kg/day) plus 700 kg agro-industrial by-products + NPN + minerals	1 400	[2] 3 000	[3] 4 300	+1 300

[1] Based on potential food production from 1/6 ha land (2 800 Mcal) and the equivalent in Mcal of 600 kg concentrate feed (viz. 2 400 Mcal).
[2] Estimated energetic cost of 120 kg NaOH + agro-industrial by-products + fuel and fertilizer inputs for 1/6 ha cultivated land
[3] Includes the equivalent in Mcal of 1 400 kg of buffalo milk containing 7 percent fat (viz. 1 530 Mcal) and the potential food production from 1/6 ha land that would be released for cultivation under this feeding regime (viz. 2 800 Mcal).

PRIORITIES FOR FUTURE RESEARCH

In the light of the above considerations, and taking account of the local resources available and the external technical assistance required, the following priority areas for future research have been identified.

Category I topics are those that are important to all countries and are basic to improving buffalo productivity the world over. They relate to problems which are technically complex and demanding in terms of investment and which are unlikely to be resolved speedily in the foreseeable future without a concerted international effort. The topics with the highest priority are straw utilization and reproductive efficiency.

Category II topics are concerned with problems which cannot be tackled by national institutions working on their own but require active cooperation with each other. International intervention in this category of topics involves assistance in the organization, implementation and coordination of cooperative research. Two topics are identified as requiring cooperative research: feed evaluation and its standardization on the one hand, and testing of different breeds and strains of water buffalo on the other.

Category III topics are those which are location- or site-specific, and can and should be resolved by national institutions, perhaps with support from bilateral funding sources. The role of international assistance here would be principally to help in evolving methods and techniques, and finding appropriate ways and means to undertake specific national tasks.

Category I

Straw utilization. The over-riding consideration here is that buffaloes in the majority of the smallholdings are fed principally on straw and supplemented with only small quantities of forages, cereal offals and oil cakes. Where straw is not used but burnt on the field, the buffaloes obtain their nutrition from grazing on communal lands and on the roadside. Green grass and weeds that

grow during the rainy season on verges, bunds and other areas unsuitable for arable cropping also contribute to the feed supply of buffaloes. But since the latter pattern of feeding cannot be expanded or continued indefinitely into the future, the inescapable conclusion is that straw will increasingly become the principal source of feed for almost all buffalo populations.

A considerable amount of research has been undertaken in both the developed and developing countries on straw utilization by cattle, but very little is known about the value of straw for buffaloes. Thus, although over 100 research reports have been published during the last eight years on alkali-treated straw, the factors affecting the degree of improvement to be expected in digestibility, growth and production in buffaloes from the use of treated straw and its supplementation with small quantities of forages, agro-industrial by-products, minerals and NPN have still not been identified. The specific items that require further research in the context of straw utilization by buffaloes are straw chemistry (in particular, straw cell wall chemistry), straw processing, supplementation of straw-based diets, and the whole subject of nutrient digestion in buffaloes, of energy, nitrogen and protein metabolism, of rumen microbiology, and of microbial protein synthesis.

Through international intervention it should be possible to create, in some of the national institutions already engaged in work in these areas, a critical mass of talent to intensify this research, which could result in a positive net annual food calorie balance and a significant contribution to human food supplies (see Table 2).

Reproductive efficiency. The elucidation of the confusing reproductive pattern in buffaloes would require a combination of complex physiological, endocrinological, nutritional, managerial and animal health investigations. The principal questions that need to be resolved relate to female fertility, male fertility and calf mortality.

With regard to female fertility, the problems requiring more thorough investigation are the late age at first calving of 40 months or more that generally prevails even among institutional herds, the high incidence (up to 30 percent) of post-partum anoestrus, and the unresolved phenomenon of "silent heat" experienced among 30 to 40 percent of the large populations of village buffaloes that have been routinely examined.

Male fertility studies require a more systematic and comprehensive research programme on spermatogenesis in the buffalo, the metabolism of spermatozoa in the epididymis, the nature and role of the seminal plasma, the detailed biochemical characteristics of buffalo semen, the changes that it undergoes during freezing and thawing, and the metabolism of the spermatozoa in the reproductive tract of the female.

Calf mortality investigations need to concern themselves basically with resolving the oft-repeated statement that "the buffalo calf has little desire to live" and at the same time developing usable technologies for reducing the incidence of buffalo calf mortality at the small farm level. In institutional river buffalo herds, calf mortality usually accounts for 25 to 40 percent of the losses, while in village herds the figure is even higher. Although a "package of practices" to lower mortality in buffalo calves has been proposed recently by one of the research institutions, it is based on a "shot-gun" approach and is therefore unlikely to be adopted at the national level in its present form.

Storing wheat straw. The average small farmer has a holding of one to four hectares and produces primarily food and cash crops. He also produces, as a by-product, about four tons of straw per hectare per year for which there is no better economic use than as livestock feed. Research on straw utilization should thus be given high priority. Photo: S.S. Chauhan

Category II

Feed evaluation. It is generally accepted by all national institutions that feed evaluation research and the establishment of practical table values are of fundamental importance for improving buffalo production. To overcome existing deficiencies in this field, a collaborative effort is required. Analytical methods should be standardized, and laboratory ring tests organized to increase the precision of the analyses. Digestibility determinations should be based on a vastly increased number of samples, and methods to determine digestibility of feeds *in vitro* would require adequate correlation with *in vivo* determinations.

International breed and strain testing. The value of an international testing programme is to obtain information on the relative genetic merits of the different breeds and strains of buf-

faloes and to utilize the results for global improvements in buffalo productivity. If dairy productivity is the principal objective, this would involve: crossing the principal breeds and strains of dairy buffaloes found in countries like Bulgaria, Egypt, India, Italy and Pakistan with swamp buffalo females under standard conditions; evaluating the first crosses for fitness and productivity characteristics; and following up the first cross by backcrossing to the parental strain to facilitate a comparison between 3/4-breds.

It is fortunate that one of the countries in the Asian and Far East region has offered to provide the facilities and bear the local costs of such an international testing programme. This would include the establishment and maintenance of a breeding population of 2 000 swamp buffalo females and of their crossbred followers. However, the additional costs of the undertaking would need to be financed internationally.

Photo: NDRI, India

Fistulated buffalo. Supplementing straw with forages, agro-industrial by-products, minerals and NPN has given variable results. Research on fistulated animals should help in understanding why this happens and the whole process of nutrient digestion in buffaloes.

Category III

The principal topics identified are the following:

- Field testing of research results, with particular reference to the generation and demonstration of new nutritional technology.
- Development of economically viable rations and feeding systems based on local feeds.
- Progeny and performance testing of young buffalo bulls.
- Evaluation of socio-economic constraints to buffalo productivity at the small farm level.
- Establishment of pilot disease recording systems and associated productivity recording.
- Building up of national documentation services to support buffalo research and development.

ORGANIZATIONAL ALTERNATIVES

Various organizational alternatives may be considered for implementing a comprehensive programme of research on the water buffalo including all of the topics listed above under the three categories. One possibility would be to strengthen an existing national institution as the focal point for all research. Unfortunately, the substantive programme areas to be covered call for a broad spectrum of research activities, and no single institution appears to be able to handle all of these in sufficient depth and with the degree of continuity, collaboration and coordination necessary to solve the practical problems of buffalo development. Although the quality of the best scientific work in some of the national institutions ranks with the best to be found anywhere else in the world, there is a great deal of unevenness and fragmentation of programmes, resulting in a dilution of effort. The alternative of creating a new international institute for buffalo research is also unlikely to be viable for the following reasons: the initial investment costs would be prohibitive; the time lag before effective results start flowing in will be unduly long because of the 6- to 6½-year generation interval in buffaloes; and the development of outreach activities between the new international centre and the various national institutions will take even longer. Thus it would be 10 to 15 years before an international research centre, set up at a very high cost, could make any significant inroads into the solution of buffalo development problems at the national level.

Another possibility is the creation of an International Board for Buffalo Research which would enter into research contracts with selected national institutions to resolve components of category I topics. This alternative suffers from two drawbacks: it will only provide piece-meal solutions to the component parts of category I topics, because comprehensive solutions would require an effective coordinating mechanism; and it would not be able to handle effectively the programmes under category II that require the active cooperation of several national institutions.

Thus the only viable organizational structure is one that would involve the

setting up of an international network of cooperating national institutions for buffalo research, guided by an international coordinating unit, with responsibility for any desired combination of category I, II and III topics. It would facilitate an efficient use of existing research personnel, equipment and funds. It would promote the development of jointly planned efforts with low capital costs. Moreover, if the planning and coordination were sound and the objectives in line with the generally accepted needs of the countries concerned, the participating national institutions would develop a sense of involvement that should result in the success of the programme. An easy transmission of its findings to national planners and decision-makers and a wide application of the results would also be possible.

However, it was recognized that, because of various constraints, the TAC and the CGIAR might wish to adopt a more limited, step-by-step approach in implementing the proposed programme. It was suggested that, if this were the case, the programme be confined in the first instance to one or both topics under category I, and that the financing for this be arranged either through the CGIAR system or bilaterally. Where the latter method is chosen, direct contractual arrangements could be made between different bilateral donors and the institutions likely to be most productive as a result of the strengthening of their research activities in a given area. Eventually, depending on the success of the initial efforts, a more comprehensive and integrated international buffalo research undertaking might be supported.

Alleviating heat stress during summer. The elucidation of the confusing reproductive pattern in buffaloes would require a combination of complex physiological, endocrinological, nutritional, managerial and animal health investigations. It has been found in institutional herds that in the absence of a wallow, free access to cold water showers during the hottest part of the day helps alleviate heat stress and contributes to improvement in reproductive efficiency. Photo: NDRI, India

DELIBERATIONS AND CONCLUSIONS

The proposals for international support to an intercountry cooperative research programme on the water buffalo as outlined in this article were discussed by the TAC. It recommended that interested CGIAR donors be urged to support either individually or collectively the activities proposed (the CGIAR concurred with this view). Follow-up action has therefore been initiated by FAO as a member of the CGIAR to determine the interest of potential donors in supporting component parts of the proposed research programme, particularly those relating to straw utilization and reproductive efficiency. The magnitude of donor support required for a five-year period to strengthen the research activities of the four leading national institutions (three in Asia and the Far East and one in the Near East) undertaking relevant work on straw utilization is estimated to be U.S.$600 000; the corresponding estimate for strengthening research on reproductive efficiency in four selected national institutions (of which one institution is common to both lines of research) is U.S.$657 500. These funds would be used principally for more intensive field and laboratory investigations, consultancies, workshops and fellowships and to a lesser extent for the purchase of equipment and rare chemicals. Such assistance is likely to have a strong catalytic effect in building up national institutions, helping them to collaborate and cooperate with each other, and developing mutually complementary programmes in areas of both regional and interregional importance. It is to be hoped therefore that the bilateral support needed to initiate the programme will be forthcoming. ■

Utilizing breed differences in growth of cattle in the tropics

J.E. Frisch and J.E. Vercoe

*The growth rate of European or British breeds of cattle (*Bos taurus*) is lower under tropical conditions than in temperate areas. Zebu breeds (*Bos indicus*) are well adapted to the tropics in terms of survival, but their growth rate is also low by temperate standards. One aspect of the work of the CSIRO Tropical Cattle Research Centre, Rockhampton, Australia, has been to analyse the reasons for the low growth rates of both breed types and consequently to determine how best to synthesize breeds which will grow well under Australian tropical conditions. As a result of this work, a simple model has been developed to help explain why different breed types grow at different rates when exposed to various environmental conditions. In this article growth is the only component of productivity which is considered. Other factors must also be taken into account when deciding on the breed best suited to a particular set of conditions.*

ENVIRONMENTAL LIMITATIONS

The main environmental factors so far identified as causing marked breed differences in growth are cattle ticks (*Boophilus microplus*), gastrointestinal helminths (mainly *Haemonchus, Cooperia, Trichostrongylus,* and *Oesophagostomum*), high ambient temperatures and solar radiation, "pink-eye" disease (bovine infectious keratoconjunctivitis), and fluctuations in both quantity and quality of feed (Frisch, 1976; Turner, 1975b). The *Bos indicus* breeds used in the studies were Brahman and Africander, the *Bos taurus* breed was Hereford × Shorthorn (HS), and the crosses between the two breed types were F_2 and later generations of Africander × HS (AX) and Brahman × HS (BX). Although only these breeds and environmental factors are shown in the model, the same general principles should apply to other similar breeds and to other parasites and diseases in tropical areas elsewhere.

Figure 1 is a diagrammatic presentation of the model. Each block is composed of segments representing the proportion of liveweight at 15 months associated with each factor and which together account for all the differences in liveweight between breeds reared under ideal conditions. The lower segment represents the liveweight at 15 months of each breed reared under field conditions at the National Cattle Breeding Station "Belmont", the research station of the Tropical Cattle Research Centre on the Tropic of Capricorn near Rockhampton, Queensland. The mean weights for each breed were HS 260 kg, Brahman 275 kg, Africander 285 kg, AX 310 kg, and BX 320 kg. These liveweights vary from year to year but are characteristic of the long-term ranking of the breeds at Belmont. They reflect comparative growth rates of the breeds grazed together under conditions of a low level of control of ticks, gastrointestinal helminths (worms) and buffalo fly (*Haematobia irritans exigua*), no alteration of heat loads, and where none of the animals was offered supplementary feed or treated for pink-eye.

Each of the other segments represents the difference in liveweight at 15 months which can be attributed to either genetic or environmental constraints on growth. It should be noted that the size of corresponding segments varies between breeds, signifying that each constraint affects liveweight to a different extent for each breed. The difference in liveweight attributable to field infestations with cattle ticks and worms has been shown in a number of studies (e.g., Seifert, 1971; Turner and Short, 1972). In the experiment of Turner and Short, for example, the increases in liveweight over a 27-week period due to dipping in acaricide at three-weekly intervals were for HS 27 kg, for AX 10 kg and for BX 3 kg. These differences accounted for about 40 percent of the mean differences between HS and BX in liveweight (15 months) recorded under field conditions over a five-year period. Although dipping increased gains in all breeds it was financially

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unrewarding, for it caused only a small increase in gain in the HS and AX over that of the undipped BX. The differential breed responses to the presence of cattle ticks were accounted for by the differences in numbers of ticks which matured on each breed. Thus the BX was least affected because it carried fewer ticks. Under conditions where greater tick burdens are carried, the effect on any breed will be greater, but the differential response will still remain. Fewer ticks mature on purebred Brahmans and Africanders relative to the BX or AX, and consequently the effect of dipping could be expected to be correspondingly less.

In the same experiment (Turner and Short, 1972) the increase in liveweight due to control of gastrointestinal helminths was for HS 18 kg, for AX 22 kg and for BX 1 kg: again a completely uneconomic practice as the undrenched BX already achieved this level of growth. These differences in helminth tolerance represent about 30 percent of the observed difference between HS and BX and more than the observed difference between AX and BX in liveweight under field conditions. Only limited data were available for the purebred Brahmans and Africanders, but at least for the Brahmans the effect of worms would be correspondingly lower than for the BX. Again it should be remembered that at higher levels of infestation the effect of worms will be correspondingly greater for each breed, resulting in greater differences between breeds.

High temperatures and solar radiation also affect the breeds differentially (Turner, 1962). There are only small differences in heat tolerance of the breeds derived from *B. indicus* which are all more heat tolerant than the HS (Vercoe, Frisch and Moran, 1972). Differences in heat tolerance account for a further 15 percent of the difference in field liveweights of the HS and BX.

Marked differences exist between the breeds in their susceptibility to pinkeye (Frisch, 1975). These differences are associated with a reduction in mean liveweight of 8 kg in the HS, 1 kg in the AX and BX, and zero in the purebred Brahmans and account for another 10 to 15 percent of the long-term

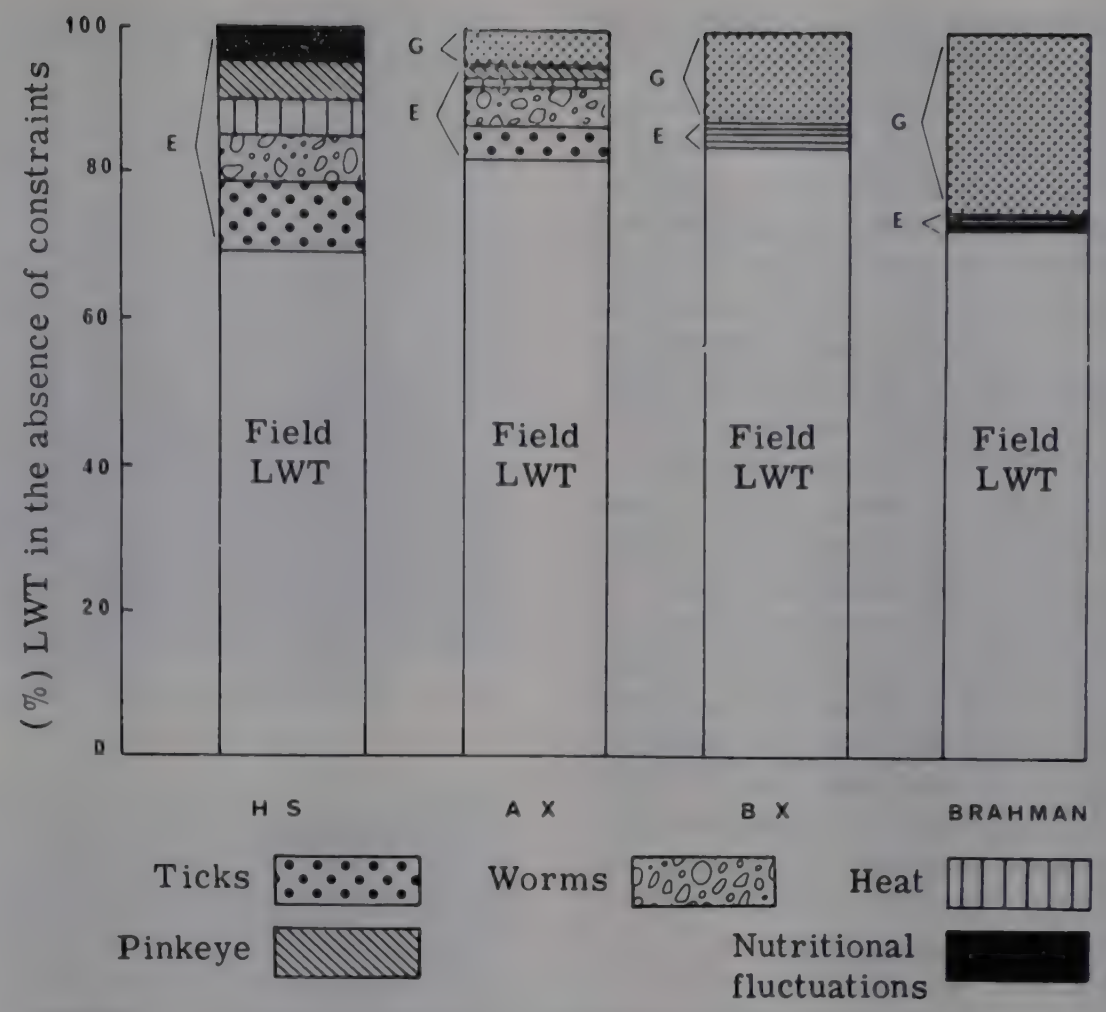

FIGURE 1. A model of reasons for differences in growth in various breeds

G = difference in liveweight caused by genetic differences in appetite

E = difference in liveweight caused by genetic differences in resistance to environmental constraints: ticks, worms, heat, pink-eye, nutritional fluctuations (see key)

LWT = liveweight at 15 months under field conditions

in liveweight at 15 months. Thus, although an occasional AX or BX becomes infected, pink-eye has a significant effect on herd well-being only in the HS or other susceptible breeds.

Breeds differ in their reaction to variations in the quantity and quality of the available feed. Genetic variation in digestive efficiency, maintenance requirement and the efficiency of utilization of energy for maintenance has been reviewed in detail recently by Warwick and Cobb (1976). Breed differences in digestive efficiency may be small, but where they have been demonstrated they generally favour the zebu-based breeds. Our recent work (Vercoe and Frisch, 1977; Frisch and Vercoe, 1976, 1977) supports the general findings of Warwick and Cobb and strongly suggests that breed differences in maintenance requirements are real. The zebu crosses have a lower maintenance requirement, which may be even relatively lower under poor nutritional conditions. Fasting metabolic rate (an index of maintenance requirement) of zebu crossbreds is also relatively lower after periods of weight loss than after periods of weight gain, as shown in the table below. It means

Breed means in fasting metabolism

	Weight loss —0.2 kg/day	Maintenance	Weight gain +0.8 kg/day
	. . . . .	*kJ/kg/day*	. . . . .
HS	86.6	88.8	97.8
AX	78.3	82.1	97.2
BX	77.0	80.3	93.4

Source: Frisch and Vercoe (1977).

that the AX and BX have the capacity to alter metabolic rate more rapidly than the HS to suit the available feed supply. This is likely to be of particular importance during drought.

These differences in feed utilization account for a varying proportion of the difference in liveweight between HS and BX depending on the fluctuations in nutritional conditions. A precise value cannot be placed on the

difference, but under conditions at Belmont it is generally about 10 percent. As with other differences shown in the model, absolute values will vary depending on conditions of measurement. It should be realized however that both the absolute and the differential effect are of importance in practical situations, and that, as the absolute effect becomes greater, the difference between resistant and susceptible breeds will increase even further.

The model shown in Figure 1 does not include any interaction effects. These have been omitted for simplicity of presentation and because known interaction effects do not alter the validity of the model. Interactions exist between constraints (e.g., the plane of nutrition affects both susceptibility to ticks and heat tolerance), but the ranking of breeds is not altered.

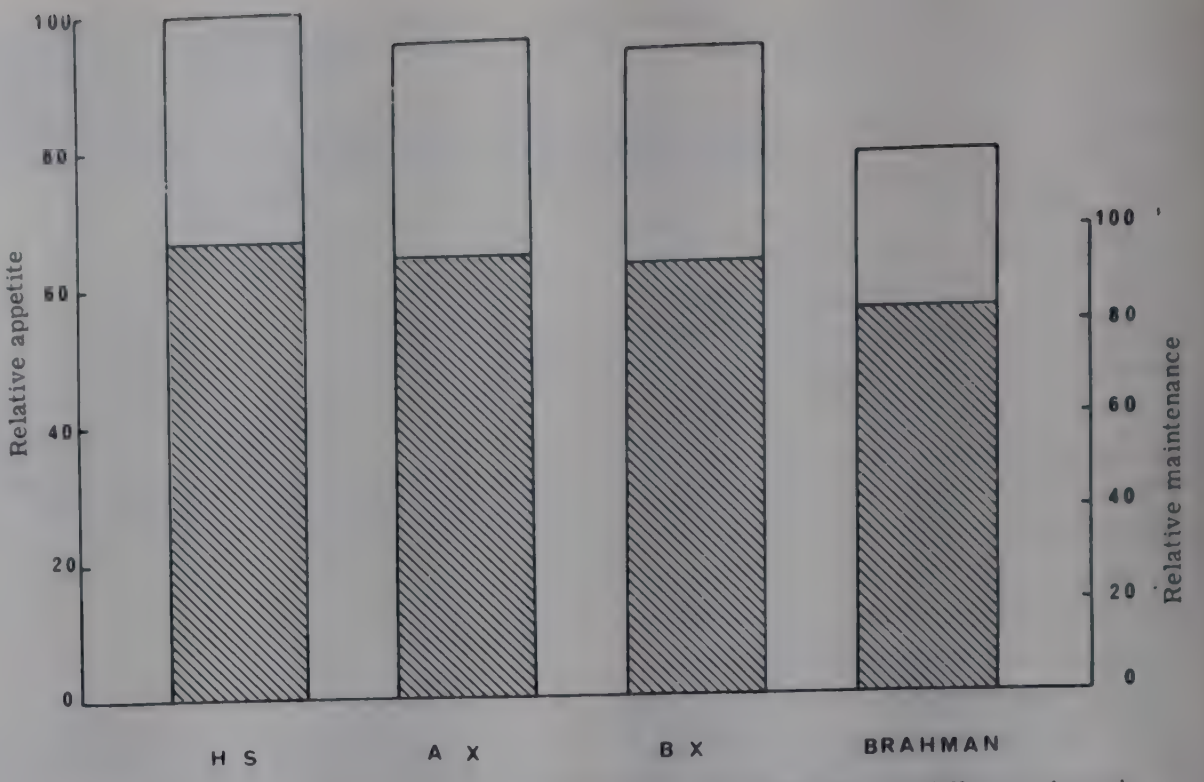

FIGURE 2. Relative appetite and maintenance requirements of different breeds

FEED INTAKE

Each of these environmental constraints acts to restrict the growth of the different genotypes to varying degrees primarily through a depression of feed intake (Bremner, 1961; Seebeck, Springell and O'Kelly, 1971; Frisch and Vercoe, unpublished). Under field conditions, where ticks, gastrointestinal helminths, heat, disease and fluctuating nutrition are all encountered, feed intake and consequently growth rate of the HS would be markedly depressed, that of the purebred Brahmans would be hardly affected, while the AX would be more affected than the BX. Despite the small effect of these environmental constraints on the voluntary feed intake of the Brahmans, they grow only marginally better than the HS and considerably slower than the AX and BX under field conditions at Belmont. In the absence of the constraints, Brahmans eat about 20 percent less feed than the HS at the same liveweight (Frisch and Vercoe, 1969). This is the only factor so far identified which accounts for their low growth rate. Under field conditions the growth rate of the HS is low because environmental constraints restrict intake; the growth rate of the Brahman is low because it has an inherently low voluntary feed intake.

The voluntary feed intake of the BX is about midway between that of the HS and the Brahman. It has inherited from its Brahman parent the ability to cope with environmental constraints; consequently feed intake and growth are only marginally reduced in the presence of these constraints. This represents in simplest terms the reason for what is often called hybrid vigour in the crossbred. It is the combination of both productive features (inherently high intake and growth rate) and adaptive features (resistance to environmental constraints) which confers on the BX the attributes essential for high growth rate under tropical conditions. Neither feature alone will give high field growth rates.

The AX is not quite as well adapted as the BX to conditions at Belmont. However, it has an inherent voluntary feed intake greater than that of the BX but less than that of the HS. In the absence of tropical environmental constraints the AX could be expected to grow more rapidly than the BX but less rapidly than the HS, for voluntary feed intake then becomes the major determinant of ranking on growth rate.

VOLUNTARY FEED INTAKE AND MAINTENANCE REQUIREMENT

The higher inherent voluntary feed intake of the HS compared to the other breeds is related to their higher fasting metabolic rates and maintenance energy requirements. Studies have demonstrated that the ratio of voluntary feed intake to fasting metabolic rate is near constant for the breeds so far examined (Vercoe and Frisch, 1977; Frisch and Vercoe, 1977). This is shown diagramatically in Figure 2, each block being composed of two segments: the lower segment represents the maintenance requirement and the upper one represents the amount of energy available for growth. The blocks represent the intakes of different breeds at similar weight and age. The larger the top segment, the higher the potential growth rate. Both intakes and metabolic rates for each breed are shown as fractions of the HS values. Thus, on the same scale, both the maintenance requirement and intake of the BX are 94 percent of the HS values.

Any differential depression of intake which occurs between breeds will alter this ratio and the amount of feed available for growth. In environments where the plane of nutrition is continually high and intake is not depressed by the other environmental constraints already mentioned, breeds with high maintenance requirements (and consequently intake) will have the highest growth rates. Thus, under optimum conditions, the HS would have the highest growth rate and the

Africander crossbred (Belmont Red) cattle in central Queensland

Above: Brahman crossbred cattle in central Queensland. *Below:* Brahman × Hereford and straight Hereford steers at Belmont

Photos: B. Toon, Department of Primary Industries of Queensland

Brahman the lowest. However, where feed intake is below its potential level for prolonged periods, either because of limitation of supply or depression caused by some environmental constraint, breeds with high maintenance requirements will suffer the highest weight losses or have the lowest and least efficient gains.

Most cattle reared in the tropics have to cope with at least the range of environmental constraints listed. Some compromise between potentially high growth rate and ability to cope with these constraints is therefore necessary when selecting breeds likely to grow most efficiently in these areas. For example, survival ability under drought conditions is enhanced in breeds having a low maintenance requirement; but when feed becomes plentiful, such breeds may gain less than those with high maintenance requirements; likewise, the rate of weight loss when feed is in short supply is also less in such breeds. This is one reason why HS cattle have higher gains than Brahman or BX cattle under feedlot conditions, but lose more weight and have lower survival rates than the *B. indicus*-based breeds during periods of drought (Frisch and Vercoe, 1969, 1977; Frisch, 1973).

The spectrum of intakes and fasting metabolic rates that exists between breeds also provides an understanding of the possible consequences of selection under conditions of high environmental temperatures. If an increase in heat tolerance is achieved by reducing fasting metabolism rather than by improving heat dissipatory mechanisms, continued selection for heat tolerance will result in reduced metabolic rate and feed intake, and consequently growth potential. This problem is being studied further at the Tropical Cattle Research Centre.

PRACTICAL IMPLICATIONS

It is evident that the relative growth performance of the various breeds is heavily dependent on the environmental conditions under which they are compared. The poorer performance of zebu crossbreds relative to *Bos taurus* breeds in favourable temperate areas can be explained by their lower ab-

solute feed intakes. Under tropical grazing conditions, where environmental constraints depress feed intake more in *B. taurus* than in purebred and crossbred *B. indicus* breeds, potential feed intake is more nearly realized in the adapted, zebu breeds and their realized growth rate is higher.

If the major environmental constraints, their relative importance, and the breeds which can cope with those conditions can be identified, it becomes possible, firstly, to predict the expected ranking for growth rates of diverse breed types and, secondly, to combine through crossbreeding complementary strengths of two or more breeds to produce the most productive animal for that environment. In addition, the desirable amounts of productive and adaptive attributes can be determined. In more favourable tropical environments a halfbred *B. taurus* × *B. indicus* may be the fastest grower, or perhaps a ¼-bred *B. indicus* if parasitic burdens are light and nutrition is good However, as environmental constraints become more severe (particularly the nutritional component), a ¾-bred *B. indicus* or even higher grades may be necessary. In each case these proportions of *B. indicus* genes are only approximate. Interbreeding to produce F_2 and later generations and selection within these segregating populations for growth under local environmental conditions are then necessary to maintain the desired combination of genes from both sides of the pedigree. It was stated earlier that growth rate is only one component of productivity, and that decisions would be influenced not only by growth rate but by reproductive performance, temperament and perhaps other factors. (See breeding schemes for increasing beef production under tropical conditions outlined by Turner, 1957b). There will always be a dilemma in deciding to what extent the environment should be modified to meet the needs of the cattle and to what extent cattle should be bred to meet the demands of the environment. In general, environmental modifications are costly, relatively temporary, and their implementation is largely a function of the prevailing economic climate. On the other hand, genetic improvement of productivity for a particular environment is relatively cheap, long lasting and cost saving.

An understanding of the relative effects of environmental constraints on various breeds and a knowledge of the growth potential of those breeds enables a rational choice of breed types for particular conditions and the definition of breeding goals for genetic improvement for that environment. The simple model generated at the Tropical Cattle Research Centre for tropical Australia contains principles which should have application to other areas. ■

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Factors affecting the location of slaughterhouses in developing countries

H.J. Mittendorf

The question of establishing slaughterhouses in producing instead of consuming areas is being raised more frequently in developing countries. The advantages to be expected from such a relocation are the additional income for the rural population from the slaughtering of animals and the processing of by-products (particularly hides and skins). This article is mainly concerned with precise cost/benefit analyses of the degree to which these expected advantages could be realized in practice.

The critical issue is the extent to which the refrigerated transport and storage facilities required for meat marketing can be introduced under given conditions at a lower cost than the transport of live animals. The cost of operating a cold chain system in developing countries should therefore be analysed and compared with the value of the meat that is lost during transport of live animals.

A brief review of current concepts governing the location of slaughterhouses in the industrialized countries is provided in the following section, followed by an analysis of what obtains in developing countries.

INDUSTRIALIZED COUNTRIES

Efficient cold chain operations (in particular, the use of refrigerated trucks) have become increasingly widespread over the last three decades in industrialized countries with the development of more efficient communication systems. It has thus proved more beneficial to transfer slaughtering operations from consuming centres to producing areas. The advantages arising from the relocation of slaughterhouses may be summarized as follows:

- Meat transport costs are lower than the costs of transporting live animals because the carrying capacity of the vehicle is used more efficiently. Moreover, the losses in both quantity and quality arising from the transport of live animals are reduced.
- Slaughtering and processing costs in well-operated slaughterhouses in producing areas are lower than corresponding costs in consuming areas, particularly when compared with the badly utilized municipal slaughterhouses still in use in some west European cities.
- The assessment of meat quality is made easier by the change from livestock to meat marketing because quality standards of the carcasses can be assessed more efficiently than those of live animals; payment according to carcass weight and quality offered by the management of slaughterhouses in the producing areas in west European countries provides an incentive to livestock owners for quality production.
- Short-term fluctuations of demand for meat in large consuming areas can be met more conveniently with meat than with live animals, resulting in a reduction of short-term market risks (in particular, of short-term daily price fluctuations).
- Flexibility in meat marketing as operated by slaughterhouses in producing areas in west European countries facilitates the marketing of wholesale cuts; this in turn improves the return from livestock sales because the retailers buy only those cuts of the carcass that can be sold in their shops, while other cuts remain at the packing plant for further processing. This is a great advantage compared with marketing through municipal abattoirs.

Because of these advantages, meat marketing has expanded remarkably in western Europe both in extent and efficiency, and slaughterings in producing areas have increased rapidly over the last fifteen years. For example, in the Federal Republic of Germany, at the beginning of the 1950s, only 5 percent of all pigs were slaughtered in private or cooperative dispatching slaughterhouses, whereas by 1975 this percentage had increased to more than 50 [1] (Böckenhoff, 1975). In

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[1] The change to meat marketing was facilitated by the abolition of the "equalization tax", which served originally to protect municipal slaughtering against competition from outside slaughtered meat.

addition, the concentration of the food retail sector in the form of supermarkets and food chains during the past twenty years has influenced the establishment of slaughterhouses in producing areas. These dispatching slaughterhouses are better able to meet the requirements of the large supermarket chains in terms of meat marketing and processing than the once predominant municipal slaughterhouses.

DEVELOPING COUNTRIES

The over-riding advantages demonstrated by the experience of the industrialized countries of establishing slaughterhouses in producing areas has exerted a considerable influence on their planning and location in the developing countries. As a result, some consultants with exclusive experience of industrialized countries have argued for establishment in producing areas without paying sufficient attention to the need to compare the relative costs and benefits of slaughtering in a producing or a consuming area. As a consequence, several slaughterhouses in Africa, established on the basis of offering a more economic system of meat transportation, have not fulfilled expectations and are at present underutilized or not utilized at all (e.g., in Ghana, Mali and Uganda). The principal error made in planning these slaughterhouses was the failure to make an accurate analysis of the comparative transport costs of livestock and meat from the producing areas to the final consumer.

Based on existing research and on observations made by the author in developing countries, the following factors would appear to deserve consideration.

Transport costs. A comparison of the relative transport costs for livestock and meat must include an accurate analysis of the losses in weight and quality suffered by livestock during transport. The cost of meat transport in refrigerated trucks is, in general, much higher in developing countries than in industrialized countries because of higher amortization charges, higher repair costs and considerably greater risks of the refrigerated unit suffering a breakdown. Quick and efficient repair services are often not available, and this is aggravated by the bad road conditions in many developing countries. Furthermore, the possibility of finding return loads of perishable food for refrigerated trucks is very limited.

TABLE 1. **Transport costs of livestock and meat in Madagascar** [1]

Item	Transport costs	
	Live animals	Carcasses
	CFA/kg carcass weight [2]	
Refrigeration	0	5
Transport	[3] 6.70	10.5
Total cost	**6.70**	**15.5**

Source: Lacrouts **et al.** (1962).

[1] Over a distance of 250 km. — [2] In 1962 1 000 CFA francs = U.S.$4.05. — [3] Including weight losses of 18 kg per head of cattle (which appear to the author to be rather high).

There is also a lack of knowledge about the magnitude of the losses, in terms of weight and quality, that are incurred during transport of livestock by truck or rail or by trekking. The losses incurred in trekking depend primarily on the manner in which the animals are driven and, in particular, on the speed at which they are moved; the length of time involved in transportation by rail or truck and the availability of feed and watering during trekking or rail or truck transport are also vital factors.

There are many areas in developing countries where quantity and quality losses during transport can be kept low, particularly during and immediately after the rainy season when there is sufficient feed. Conversely, weight losses tend to be higher toward the end of the dry season.

In analysing weight loss a distinction has to be made between excretory shrinkage (the loss of the contents of the intestine) and tissue shrinkage. Excretory shrinkage is due to faecal, urinary and moisture losses (sweating and respiration) which hardly affect the economic value of the animal. Tissue shrinkage starts when the quantity of nutrients absorbed from the gut falls below the level necessary to support the animal's physiological activities. This results in a loss of "meat", the quantity of which depends upon the mode and length of transport. Research carried out on weight losses of cattle by Mittendorf and Böckenhoff (1957) and Böckenhoff (1960) in the

Transport of cattle by truck in Ivory Coast is economic where roads are relatively good

Photo: OMBEVI

TABLE 2. **Transport costs of livestock and meat in Ghana (1968)**

Meat transport [1]		Livestock transport	
	Ncedis [2]		Ncedis
Cost per animal (1/30 of 591)	19.70	Cost per animal	10.00
Loss of value of edible by-products	9.00	Loss (1.5%)	1.80
Total: Bolgatanga/Accra	28.70	Loading & unloading	.60
		Municipal tax	.10
		Holding ground fee	.50
Total: Bolgatanga/Kumasi (2/3 of 28.70)	19.00	Total: Bolgatanga/Kumasi	13.00

Source: Reusse (1968).

[1] Cost per load of 30 carcasses (in new Cedis): amortization — 210; interest on capital — 36; insurance — 80; maintenance and repairs — 100; tires — 50; petrol — 75; driver and co-driver — 20; administration — 20: total — 591.

Capital outlay on a truck in Bolgatanga:

	Capacity	Price (Ncedis)
(i) MAN 405 for cattle with locally built body	4.5 tons or 12 cattle	9 000
(ii) MAN 405 refrigerated truck (imported)	3.5 to 4 tons or 12 carcasses including by-products (2 to 2.5 tons)	16 000
(iii) MAN 405 refrigerated truck with semi-trailer (imported)	6 to 7 tons or 30 carcasses with by-products	32 000

Excluding refrigeration costs at slaughterhouse and at the market in Kumasi.
Assumptions: life of trucks 3 years; one trip weekly to Accra = 150 × 1 930 km viz. 289 500 km; loading 30 carcasses.

[2] In 1968 1.00 Cedis = U.S.$0.98.

Federal Republic of Germany showed that, during transportation over 400 km, approximately 1.5 percent of the carcass weight was lost, which would otherwise have been available if the animals had been slaughtered in producing areas.

Similar experiments under developing country conditions are not known to the author. The Meat Marketing Board in South Africa conducted an experiment to assess tissue shrinkage during transport of cattle from Walvis Bay, Namibia, to Cape Town, South Africa, a distance of over 2 500 km (Mittendorf and Wilson, 1961). Rail transport over this distance required approximately four days, and the cattle had to be unloaded twice for feeding and watering. The tissue shrinkage was estimated at about 1.5 percent of the carcass weight and was thus in line with the results reported by Böckenhoff. A detailed cost/benefit analysis of livestock transport costs compared with meat transport costs between Walvis Bay and Cape Town showed that it was not economic to establish a cold chain in an attempt to eliminate the livestock weight losses incurred during rail shipment; the value of meat losses, 3 kg per animal (1.5 percent × 200 kg carcass weight), was much smaller than the cost of refrigerated transport. It was recommended at the end of the 1950s that a reduction in transport time should be achieved by introducing diesel locomotives capable of greater speeds.

From this research and from other observations it can be concluded that during the transport of live animals in developing countries shrinkage as well as bruising can be kept at a low level. Where losses are considerably higher than indicated above, an inquiry should be made as to what can be done to reduce weight losses of live animals during transport.[2]

Slaughter costs. The relocation of slaughterhouses from consuming to producing areas in industrialized countries results in reduced slaughter costs because of generally lower labour costs and more efficient utilization of slaughtering facilities, but it does not necessarily follow that the same results would be obtained in developing countries. Salaries paid in rural and urban areas in many developing countries do not vary substantially in view of the high unemployment in most cities. Other operating costs, such as amortization, plant repairs, and the costs of infrastructure (e.g., communications) are in most cases higher in rural areas.

Hides, skins and other by-products. Importance is too often placed on the possibilities for earning additional revenue from processing hides and skins and other by-products when animals are slaughtered in producing areas. However, in many developing countries, the demand for meat and bone meal is concentrated mainly in the neighbourhood of the urban areas where intensive poultry and pig production has developed, while in the distant, extensive cattle and sheep raising areas there is only a negligible market for these products. This situation has been particularly disadvantageous to the slaughterhouses in the Sahelian zone of west Africa.

The processing of hides and skins in producing areas also has the disadvantage of being generally more expensive because of the smaller numbers processed, increased energy costs, and the higher cost of chemicals. A further disadvantage is the reduced quantities of supplies of leather which do not meet the concentrated demand of the large leather manufacturing industries of the industrialized countries.

Other factors. Other factors favouring meat transport in west European countries (improved conditions for quality assessment, better incentives for quality production, more favourable opportunities for supplying urban areas, and the improved scope for meat processing) are less important in influencing the choice between livestock and meat transport in developing countries.

Field studies

The following field studies and/or observations are relevant to the problem

[2] In order to clarify the economics of different transport means for livestock, it is essential that systematic research on weight losses during transport of livestock and their reasons be promoted; as examples, reference may be made to Raikes and Tilley (1975), Shorthose (1965) and Shorthose *et al.* (1972). Pander (1975) began a study in Zambia to assess the weight losses of livestock during transport, without however distinguishing between losses due to excretory or tissue shrinkage.

of the location of slaughterhouses in developing countries.

Madagascar: A comparative analysis of livestock and meat transport in Madagascar was conducted by Lacrouts *et al.* (1962). The results, summarized in Table 1, show that under the conditions of this study the cost of meat transport was twice as high as the cost of livestock transport even though high tissue shrinkage was assumed to have occurred during livestock transport.

Ghana: An analysis by Reusse (1968) on the economics of the slaughterhouses in Bolgatanga in northern Ghana showed that transport of meat could not compete with livestock transport since, in addition to higher transport costs, lower returns from edible by-products were obtained. In west Africa the latter contribute about one sixth of the total value of an animal at the retail level if offered in fresh form, but they lose 25 to 50 percent of their retail value once they are frozen for transport. In the transport costs summarized in Table 2, the additional expenditure items for cold storage at the slaughterhouse and at the receiving point in the urban area, which are essential under tropical conditions, are not included.

Mali: The slaughterhouse in Gao, Mali, was established during the period 1962-65 with a capacity of 1 900 tons for the purpose of making meat supplies available for transport by air to the west African coastal areas. This slaughterhouse has never become operational. An analysis conducted subsequently on the comparative cost of live animals and meat has shown that the transport of meat was much too expensive to be competitive with livestock transport (Table 3). The recommendation was therefore made that the slaughterhouse be used for other purposes, and that improvements to the existing system of transportation would prove more beneficial (FAO, 1971).

An important disadvantage brought out in Table 3 is the large foreign currency component involved in meat transport. This includes energy costs, air transport costs and slaughtering and refrigeration costs, which in terms of

TABLE 3. **Comparison (in Malian francs) [1] of marketing costs and margins for beef carcasses from Gao (Mali) to Kumasi/Accra (March 1971)**

Price and costs	Export of cattle: Export price		Price and costs	Export of carcasses (carcass weight 170 kg): Export price	
	Actual	Excluding component in hard currency		Actual	Excluding component in hard currency
I. Assumed sales price					
Sale price of the steer in Ghana (Kumasi)	81 500		Sales value per carcass in Ghana (Accra)	94 400	
Less Ghana import duty	11 500		Less Ghana import duty	24 700	
Net sales value	70 000		Net sales value	69 700	
II. Less main costs					
Assumed purchase price	35 000	—	Assumed purchase price	35 000	—
Buying fee	1 500	—	Slaughter costs and cold storage [3]	5 100	3 000
Vaccination	300	150	Transport costs slaughterhouse to airport [3]	800	500
Export tax	1 500	—	Airfreight [3]	25 700	21 800
Trekking fee	4 000	[2] 2 000	Sales costs in Accra	700	700
Transport in Ghana	5 550	5 550	Loss of weight including quality	1 300	1 300
Transit duty in Upper Volta	1 000	1 000	Value of hides and by-products locally sold	—1 300	—1 300
Ghana veterinary fee	250	250			
Other costs in Ghana	3 000	3 000			
Loss of weight (5% of costs)	3 100	3 100			
Total	**55 200**	**15 050**		**67 300**	**26 000**
III. Surplus or loss (I less II)	**14 800**	**54 950**		**2 400**	**43 700**

Source: Fenn (1971).

[1] In 1971 1 000 Malian francs = U.S.$1.80. — [2] It is assumed that 50% of the expenditure occurs outside Mali. — [3] It is assumed that 60% of the refrigerated cost, 60% of transport costs, 85% of a[illegible] transport have to be paid in hard currency.

Photo: OMBEVI

Trekking of cattle from the Sahelian zone of west Africa to the coast is still a common method of transport. Here, 300 head of cattle are guided by six herdsmen on the way from Mali to Ivory Coast. Stock-route development is essential to reduce losses.

local currency are often undervalued because of the over-valuation of the local currency.

Chad: The slaughterhouse at Ndjamena, Chad, was completed at the end of the 1950s for the purpose of providing meat for transportation by air to Douala (Cameroon), Kinshasa (Zaire) and Libreville (Gabon). This slaughterhouse was well utilized for many years not only because air transport offered the only means in this case of reaching distant markets, but also because suitably high prices were obtained for the meat so transported.

Bolivia: Meat has also been successfully transported by air in recent years from the producing areas in the lowlands of Beni to La Paz; as in Chad, this was the only means by which a market could be reached.

CONCLUSIONS

The question of the optimum location of slaughterhouses in producing or consuming areas is, in principle, one to be decided mainly on the basis of the comparative costs of livestock or meat transport. In industrialized countries it is generally more economic to establish slaughterhouses in producing areas because meat transport is more economic than livestock transport. But as far as developing countries are concerned, most of the studies carried out to date suggest that under present conditions the establishment of slaughterhouses in consuming areas is generally more economic because the transport of meat is usually more expensive than that of livestock. The costs of a cold chain operation from a slaughterhouse sited in a producing area to an area of consumption are considerably higher in developing countries than the costs of comparable operations in industrialized countries. Conversely, meat prices in developing countries are, in general, lower than in industrialized countries. This differential price/cost relationship does not therefore justify investment in such a capital-intensive marketing technique as the cold chain. Livestock transport may appear to be physically more wasteful, but in many developing countries it is more economic than transporting meat.

Methods of reducing high tissue shrinkage during trekking or transport of live animals should be investigated. Improvement of stock routes and holding grounds, reduction of transport time on railways, and the provision of watering facilities all offer considerable opportunities for reducing shrinkage and costs of marketing under many conditions; action on these lines should be encouraged. ■

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The use of non-milk proteins in milk substitutes for calves

I.J.F. Stobo and J.H.B. Roy

It is only in comparatively recent times that man, by his advances in both crop and animal husbandry techniques, has changed the role of the ruminant from that of an animal capable of utilizing roughage, often of very poor quality, to that of a domesticated animal able to utilize high-energy feeds, such as concentrates, and good-quality roughage, with a very marked improvement in output of animal products. Despite this marked progress in manipulation of output by improved nutrition of the older ruminant, the newborn calf is still dependent on its mother's colostrum for protective antibodies until it has developed its own active immunity to disease.

Under natural conditions, the calf sucks its dam on about six to eight occasions per day at first, declining gradually to about three or four times. Although the calf may start to eat solid food from about one week of age and can be weaned on to a high-concentrate diet from about five weeks, a plentiful supply of milk may extend the suckling period even until the calf is as old as nine months. However, when milk is required for human use, calves are frequently separated from the dam at about two days of age and given limited quantities of milk by bucket, usually in two feeds per day, the remaining milk being available for human consumption as liquid milk or for processing for human or animal use.

In the developed countries technological advances were made in the 1950s enabling satisfactory milk substitutes for calves to be based on skim milk and added fats of animal or vegetable origin, and these have been fed to calves from as early as two days of age. For some considerable time attempts have been made to replace part of the skim milk in milk substitutes by cheaper sources of protein. There is no doubt that the demand for increasing quantitites of whole and skim milk for human use in developing countries is likely to stimulate attempts to use substitutes for milk protein in the rearing of calves. A considerable amount of research has already been done on possible alternative protein sources, but before the merits of these are discussed, it is important to outline the main features of the digestion of milk protein by the calf.

Digestion of milk protein. In the healthy neonatal calf milk or a milk substitute containing at least 60 to 70 percent skim milk passes by way of the oesophageal groove direct to the abomasum or fourth stomach (Ørskov, 1975). Within a few minutes the action of the acid and enzymes secreted by the wall of the abomasum causes coagulation of the casein, incorporating the fat, into a firm clot. Frequent muscular contractions of the stomach assist in the release of the whey fluids, containing the lactose, whey proteins including a small quantity of immunoglobulins, and much of the minerals, which pass to the small intestine. For calves given milk diets once or twice daily, the whey passes rapidly from the abomasum during the first 3 to 4 hours and then at a slower rate until complete passage has occurred by 9 to 13 hours (Mylrea, 1966; Ternouth *et al.*, 1977). The casein clot is degraded gradually by the enzyme action of rennin and/or pepsin and hydrochloric acid, and the partially digested proteins and the fat are released at a fairly continuous rate over 24 hours, with the main passage between 4 and 10 hours after a feed. Thus, when the calf has two or more feeds per day, some of the clot from the previous meal is incorporated in the new clot. On passing to the small intestine, further enzyme action by trypsin, chymotrypsin and carboxypeptidases present in the pancreatic juice, and by other peptidases secreted into the small intestine, is followed by absorption from the small intestine of much of the nitrogen as amino acids.

In contrast, if the skim milk has received "severe" heat treatment (e.g., a preheating treatment of 74°C for 30 minutes, as opposed to 77°C for only 15 seconds [Roy, 1969]), digestive disorders are likely to occur especially in the very young calf, under conditions of marginal passive immunity from colostrum, or in an adverse microbiological environment. The clotting properties of "severely" heat-treated milk are reduced and a floccu-

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lent precipitate is formed in the abomasum instead of a firm curd. Gastric digestion is impaired as a result of reduced acid and enzyme secretion (Williams, Roy and Gillies, 1976) and undigested casein escapes into the duodenum. As the output of proteolytic enzymes from the pancreas is also reduced, the overall effect is a reduction in the digestibility of protein, fat and mineral matter. In consequence, liveweight gains are frequently reduced and diarrhoea and even deaths can occur. The contrasting effect of "mildly" and "severely" heat-treated milks on gastric digestion is demonstrated in Figure 1.

In has thus become apparent that the physical effect of clotting, or some factor closely related to it, is of paramount importance in the digestion of milk by the neonatal calf. On the present evidence, it appears that the newborn calf, in comparison with other species, is much more adversely affected by poor clot formation in the stomach; this may reflect the much greater proportion of nitrogen present in the form of casein (about 80 percent) in bovine milk than in that of other species.

Part of the function of clotting of the ingested milk seems to be to provide a means of ensuring a slow but continuous supply of nutrients at the sites of absorption in the small intestine. Although the harmful effects of excessive heat treatment of milk becomes less as the calf grows older, the possibility of replacing a large proportion of the milk protein in milk substitutes by non-milk proteins, especially during the first three weeks of life, must be viewed with a certain amount of scepticism.

Substitutes for milk protein. When some or all of the skim milk is replaced by an alternative protein source, the use of additional whey, lactose or other simple carbohydrate may be necessary to maintain the "normal" chemical composition: 200 g fat, 240-280 g crude protein, 450-490 g carbohydrate, and 70 g ash/kg dry matter. However, the limited ability of the neonatal calf to digest starch, as opposed to lactose or even glucose, precludes the use of more than 5 to 10 percent of even a partially hydrolyzed starch product if digestive upsets are to be avoided. Moreover, the high carbohydrate content of some vegetable protein sources may determine the maximum level of inclusion unless a protein concentrate is prepared from the vegetable protein source.

Apart from being easily digested, any protein substitute should have a suitably balanced content of the essential amino acids, and toxic factors must be absent. Consistent composition for different batches of the same product is also essential. Physically, the product should be free-flowing but not dusty, have good storage properties, have good suspension properties in water, and must be palatable. Palatability is most important because, if the calf is not keen to drink its milk, the reflex closure of the oesophageal groove may not occur and the liquid diet will pass to the rumen, often resulting in bloat which may be fatal. The economics of production and constancy of supply are other factors which need to be considered.

Many protein products have been examined as possible replacements for skim milk in the diet of the calf. The most widely available products have been prepared from soybean, fish, or, more recently, from single-cell proteins (SCP), grown on a variety of substrates, although sources such as whey, meat hydrolysates, field bean, pea, rapeseed and potato proteins are worthy of mention. The amino-acid composition of milk protein and some of these alternative protein sources is presented in Table 1. As the first-limiting amino acid for the pre-ruminant calf is invariably methionine, these protein sources appear to possess the essential amino acids in roughly the correct proportions to be classified as "suitable" substitutes for milk protein, especially as the diets can easily be supplemented with synthetic amino acids if necessary.

Numerous growth and digestibility trials have been made to assess the suitability of non-milk proteins for the pre-ruminant calf, often with widely different results. This, however, is not surprising, since critical examination of the results obtained reveals not only that physical and chemical treatment may have markedly affected the product, but also that conditions such as age of calf, level of inclusion of non-milk protein, and level of feeding may have been substantially different.

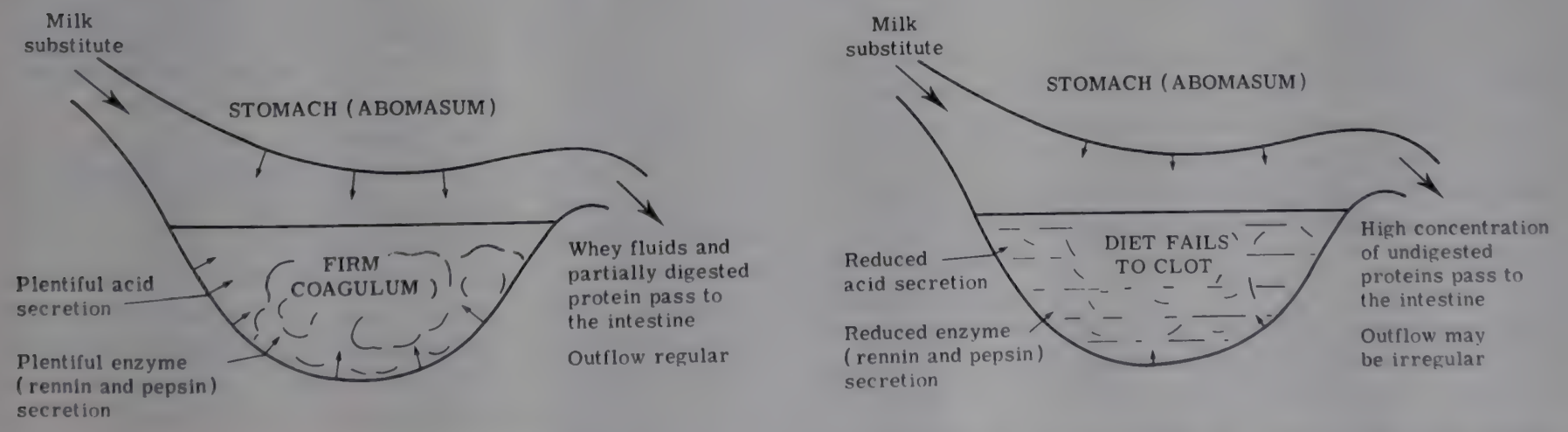
Milk substitute
STOMACH (ABOMASUM)
FIRM COAGULUM
Plentiful acid secretion
Plentiful enzyme (rennin and pepsin) secretion
Whey fluids and partially digested protein pass to the intestine
Outflow regular
Milk substitute
STOMACH (ABOMASUM)
DIET FAILS TO CLOT
Reduced acid secretion
Reduced enzyme (rennin and pepsin) secretion
High concentration of undigested proteins pass to the intestine
Outflow may be irregular

FIGURE 1. Effect on gastric digestion in the calf of giving (*left*) unheated or "mildly" heat-treated milk protein which clots readily in the abomasum; and (*right*) "severely" heat-treated milk, or milk substitute containing a large proportion of non-milk protein, which does not form a clot

TABLE 1. **Amino-acid composition of skim milk and some non-milk protein sources**

Amino acid \ Sources	Dried skim milk	Dried whey	Solvent extracted soya flour	Fish protein concentrate	Single cell proteins		
					"Toprina" [1]	"Pruteen" [2]	"Pekilo" [3]
	Crude protein content (g/kg DM)						
	360	130	520	800	600	780	440
	g/16 g nitrogen						
Aspartic acid	8.1	7.9	9.5	8.5	10.4	8.4	9.4
Threonine	4.6	5.9	3.4	4.2	5.2	4.5	4.6
Serine	6.2	4.7	4.5	4.2	5.2	3.0	4.5
Glutamic acid	22.2	15.2	15.6	13.3	13.6	9.4	10.6
Proline	9.8	5.1	4.7	5.5	4.6	3.4	4.2
Glycine	2.1	2.1	3.7	5.2	4.7	4.4	4.5
Alanine	3.5	4.3	4.2	5.8	7.4	7.2	6.7
Valine	7.4	5.5	4.5	4.8	5.2	5.9	5.1
Cystine	1.2	2.3	1.3	1.1	1.0	0.6	0.8
Methionine	2.4	1.3	1.3	2.6	1.6	2.4	1.4
Isoleucine	5.5	5.1	4.4	3.7	4.3	4.3	4.4
Leucine	11.6	9.7	7.5	7.4	7.1	7.3	6.6
Tyrosine	4.8	2.4	3.4	2.8	3.1	3.1	2.9
Phenylalanine	4.9	2.8	4.5	3.5	3.8	3.7	3.8
Lysine	7.7	5.2	5.6	7.6	7.1	5.9	6.3
Histidine	2.5	1.3	2.2	2.2	1.8	1.8	1.9
Arginine	3.7	2.0	6.5	6.0	4.2	4.9	6.2
Tryptophan	1.4	1.6	1.3	1.4	1.2	1.0	1.1

[1] Yeast protein (B.P. Proteins Ltd, London).
[2] Bacterial protein (Imperial Chemical Industries, Billingham, Cleveland, U.K.).
[3] Fungal protein (Tampella AG, Tampere, Finland).

Selected data are presented in Table 2 for the apparent digestibility of total nitrogen in milk substitute diets based on milk protein or in which various proportions were supplied by individual protein sources of vegetable, animal or SCP origin. It is clear that, in general, the apparent digestibility of total dietary nitrogen was reduced as the level of inclusion of non-milk protein was increased, although this reduction was less for calves older than one month than for younger animals.

Soya products. Shoptaw (1936) was probably the first to report that a milk substitute containing finely ground soybeans as the sole protein source for young calves resulted in diarrhoea, loss of appetite, muscular weakness, high mortality and poor growth rate of surviving calves. Since that time innumerable experiments have been made in an attempt to define the detrimental factors in soya and to develop satisfactory processing methods that would enable soya products to be used in milk substitutes. The literature has been reviewed by Ramsey and Willard (1975) and by Roy (1977), from which it is clear that there are still many aspects which are not understood fully.

The earlier work suggested that the most highly refined soya products resulted in the best performance. Thus, the extraction of fat from soya flour and also of carbohydrate to produce a soya protein concentrate, combined with toasting to destroy trypsin inhibitor and haemagglutinins, all brought about some improvement in calf performance. However, even diets containing refined soya, supplying a large proportion of the dietary protein, were often unsatisfactory, since low digestibility and a high incidence of diarrhoea seemed to be inherent properties, which were especially adverse for the very young calf. This may partly be explained by the reduction in the secretions of gastric acid and enzymes (Williams *et al.*, 1976) and of pancreatic protease (Ternouth *et al.*, 1975) that were observed when soya flour supplied between 42 and 83 percent of the protein in a milk substitute.

Physiological studies have recently indicated that the use of acqueous ethanol, rather than water, to extract soluble carboydrate in the preparation of a soya protein concentrate prevented the rapid passage of nitrogen, sometimes preceded by gastric stasis, through the small intestine. The build-up of antibodies to soya protein was also eliminated when ethanol-extracted soya protein concentrate was used Despite these advances, it may well be that high levels of soya cannot give satisfactory results until conditions within the abomasum have changed from those conducive to rennin proteolysis to those more suitable for digestion by pepsin, possibly at a lower pH. Such changes take place gradually with age and may not be sufficiently advanced until the calf is between 3 and 4 weeks of age for soybean protein to supply more than about 40 percent of the total protein in the milk substitute diet.

Other sources of vegetable protein. Satisfactory results have been reported for calves given milk substitutes in which field bean, pea, potato or rapeseed has provided a fairly high proportion of the dietary protein. However, digestibility of protein has been considerably reduced at a young age, although there have been no reports of trypsin inhibitor or of allergic reactions being involved. In general, it would seem that insufficiently large quantities of any of these products are available to make a serious impact on milk substitute composition.

Fish products. Fish products are variable in composition, partly as a

TABLE 2. **Apparent digestibility of nitrogen and coefficient of nitrogen retention by calves given milk substitute diets containing various protein sources**

Protein source (and protein content - g/kg)	Protein content of diet (g crude protein/kg DM)	Proportion of milk protein replaced	Age (days)	Digestibility of total nitrogen of diet	N retention (g/g N intake) [1]	Reference
1. Cow's milk	272	—	28-35	0.93	0.62	Roy *et al.*, 1964
Skim milk	359	—	28-35	0.95	0.42	Roy, Stobo and Gaston (1970)
Fat-filled skim milk	294	—	28-35	0.95	0.53	Roy *et al.*, 1970
2. Whey powder (130)	264	0.05	7-14	0.88	0.61	Stobo and Roy (1977)
			28-35	0.90	0.49	
			70-77	0.92	0.36	
	260	0.11	26-96	0.95	0.61	Paruelle *et al.*, 1973
3. Concentrated whey, delactased (278)	208	0.50	12-67	0.83	0.40	Raven (1972)
4. Soybean, full fat, unheated (425)	287	0.40	15-19	0.53	0.31	Nishimatsu and Kumeno (1966)
			35-39	0.76	0.50	
defatted, heated (500)	170	0.35	21-26	0.76	0.41	McGilliard *et al.* (1970)
			49-54	0.85	0.57	
		0.50	21-26	0.68	0.30	
			49-54	0.74	0.42	
defatted, heated, alkali-treated (528)	290	0.36	7-14	0.78	0.54	Roy *et al.* (1977)
			28-35	0.84	0.52	
			7-14	0.66	0.47	
		0.70	28-35	0.64	0.40	
concentrate, alcohol extracted, heated (710)	210	0.70	21-28	0.82	0.40	Gorrill and Nicholson (1969)
			42-49			
concentrate, extracted (650)	321 Raw	0.82	28	0.76		Nitsan *et al.* (1971)
	321 Partly heated		28	0.82		
	300 Heated		28	0.90		
isolate (900)		1.0	7-14	0.75	0.30	Porter and Hill (1963)
			28-35	0.87	0.38	
5. Pea, flour (290)	268	0.52	7-12	0.53		Bell, Royan and Youngs (1974)
			13-18	0.72		
			19-24	0.74		
concentrate (615)	245	0.50	7-12	0.50		
			13-18	0.76		
			19-24	0.79		
6. Fish, flour (700)	220	0.33	7-12	0.86	0.38	Huber and Slade (1967)
			42-49	0.91	0.50	
		0.67	7-12	0.84	0.41	
			42-49	0.90	0.54	
		1.00	7-12	0.80	0.24	
concentrate (900)	271	0.73	15-21	0.82	0.65	Paruelle *et al.* (1974)
			24-34	0.89	0.65	
concentrate (770)	288	0.33	7-14	0.77	0.52	Roy *et al.* (1977)
			28-35	0.84	0.51	
			70-77	0.89	0.40	
	270	0.61	7-14	0.69	0.48	
			28-35	0.77	0.46	
			70-77	0.87	0.44	
7. Abattoir by-products						
Dried blood (900)	208	0.50	12-67	0.78	0.35	Raven (1972)
Meat meal (795)	207	0.50	12-67	0.79	0.33	Raven (1972)
Meat solubles (850)	195	0.33	10-17	0.55	—0.10	Polzin *et al.* (1976)
			17-24	0.66	0.07	
			24-31	0.72	0.23	
8. Single cell proteins						
Dried bacterial sludge (600)	267	0.50 and 0.78	4-14	0.75	0.25	Bouchard, Brisson and Julien (1973)
			15-24	0.86	0.50	
			25-33	0.90	0.62	
Dried yeast (B.P. Proteins Ltd) (613)	278	0.22	7-14	0.80	0.55	Stobo and Roy (1977)
			28-35	0.83	0.47	
			70-77	0.88	0.37	
Dried bacterial cells (ICI) Ltd) (776)	284	0.22	7-14	0.79	0.52	
			28-35	0.88	0.46	
			70-77	0.91	0.37	
	305	0.44	7-14	0.77	0.44	
			28-35	0.85	0.38	
			70-77	0.89	0.30	

[1] Efficiency of nitrogen retention may also be affected by level of feeding and by protein content of the diet.

result of the great variety of raw materials that may be used (e.g., white fish or herring, the extent of boning or removal of offal) and partly as a result of the extraction method employed. Nevertheless, the amino-acid pattern of fish protein closely resembles that of milk protein.

The early trials in which fish meal was used were not very successful, high mortality, digestive upsets and poor growth rates being reported especially for young calves and vitamin E deficiency and anaemia for older animals. Removal of the fat to produce a fish protein concentrate (FPC) tended to give better results, although it is recognized that removal of the water-soluble protein fraction may also be desirable. There are conflicting reports on the effects of using isopropanol, dichloroethane or hexane as the extraction solvent, with some suggestion that dichloroethane may result in toxic residues in the product unless a final extraction with ethanol is used.

The review by Huber (1975) and Roy (1977) indicates that up to about 40 percent of the protein in a milk substitute could be supplied by FPC without undue reduction in performance of calves during the first three weeks of life. When calves have access to dry food, the reduced digestibility of nitrogen (Table 2) does not seem to be detrimental, and up to 70 percent protein replacement is possible.

Milk substitutes containing fish products tend to be palatable to the calf and promote gastric acid secretion with only a marginal decrease in abomasal enzyme production. Thus, despite the lack of coagulation, the digestive system of the neonatal calf seems capable of tolerating a greater proportion of the protein in the milk substitute from FPC than from a vegetable protein source. As with other non-milk proteins, there is a marked improvement in digestibility between one and four weeks of age.

Other sources of animal protein. A considerable quantity of dried whey is produced as a by-product of the cheese industry. Since whey contains only about 130 g protein/kg dry matter it is often included in milk substitutes for calves, either to reduce the protein content of a diet based on skim milk and added fat, or in conjunction with a non-milk protein source of high protein content to allow a major proportion of protein substitution without increasing the protein content of the diet above 240-280 g/kg dry matter. There is some evidence to suggest that sweet whey and acid whey neutralized with sodium hydroxide are more suitable products than acid whey *per se*. Delactosed and demineralized whey, which has a relatively high protein content, can probably supply a large proportion of the dietary protein, while heat-precipitated whey protein has been used successfully as the sole source of protein, although protein digestibility at 14 days of age was low.

Practically all other sources of animal protein used in milk substitutes are obtained as by-products from the abattoir. The use of dried blood and meat meal was reported by Raven (1972) to result in marked depressions in digestibility of organic matter and crude protein, as well as in nitrogen retention. In contrast, Bonsembiante and Parigi-Bini (1971) recommended the replacement of 20 percent of milk protein by hydrolyzed slaughter by-products for veal calves, although weight gains were reported to be depressed slightly during the initial period.

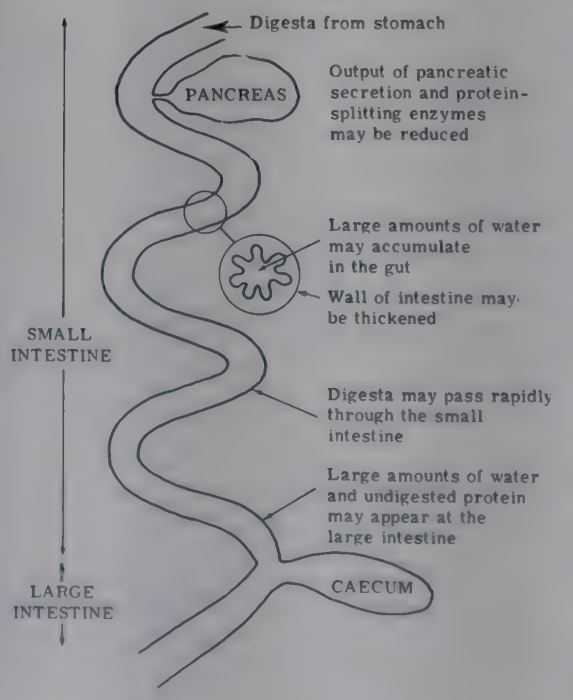
Digesta from stomach
PANCREAS
Output of pancreatic secretion and protein-splitting enzymes may be reduced
Large amounts of water may accumulate in the gut
Wall of intestine may be thickened
SMALL INTESTINE
Digesta may pass rapidly through the small intestine
Large amounts of water and undigested protein may appear at the large intestine
CAECUM
LARGE INTESTINE

FIGURE 2. Effect of a "severely" heat-treated milk protein, or of non-milk protein, on digestive function in the small intestine of the calf

Single cell proteins. The comparatively recent development of methods of production of SCP, notably yeast and bacterial proteins, has stimulated much interest in their suitability for use in the diets of pigs, poultry and the pre-ruminant calf. As shown in Table 1, apart from a somewhat low methionine content in "Toprina" and "Pekilo" proteins, SCP have a reasonable amino-acid composition. Moreover, exhaustive tests have failed to reveal any toxicity associated with the products so far available, and the calf is able to metabolize nucleic acids to simple products which can be excreted.

In common with other non-milk proteins, the digestibility of protein in diets containing SCP is low at a young age and increases subsequently, the extent of the reduction being related to the amount of milk protein replaced by SCP. Particle size of the SCP may also be of considerable importance, since a yeast micro-ground to 50 μm diameter was digested better than the same product of 200 μm diameter (Paruelle *et al.*, 1972). To avoid excessive dustiness of the product, a small quantity of soybean oil is sometimes included. Although some workers have recommended that SCP should supply a maximum of 15 percent of the dietary protein, Stobo and Roy (1977) reported that calves restricted to milk substitute diets containing 22 percent of the protein as either yeast or bacterial protein had similar weight gains to those given milk protein (1.1 kg/day from birth to 12 weeks); performance declined to 0.94 kg/day when 44 percent of the protein was supplied by SCP. Nevertheless, as shown in Table 2, overall protein digestibility in the diet between 7 and 14 days was only 0.80, and weight gain during the first three weeks was slightly reduced even when SCP contributed 22 percent of the dietary protein.

Assessment of non-milk protein sources. It is clear that the greater the quantity of non-milk protein included in a milk substitute, the less likely is coagulation to occur in the calf's abomasum; this condition arises partly as a result of the reduction in acid and rennin secretion and partly as a result of the dilution effect on the

FIGURE 3. Cross-section of the small intestine at a distance of one metre from the pyloric sphincter obtained from calves slaughtered at 13 weeks of age which had been given from two days of age either a good quality milk substitute ("normal," *left*) or a diet in which 44% of the protein was from a single cell protein source (thickened, *right*)

amount of casein present. The resultant impaired gastric digestion of protein and increased escape of undigested protein from the abomasum are basically similar to the situation that arises when a "severely" heat-treated milk is given. In the small intestine the output of proteolytic enzymes may be reduced, digesta may pass rapidly through the small intestine and large amounts of water and undigested protein may arrive at the large intestine, as illustrated in Figure 2.

An additional feature observed with non-milk proteins is the thickening of the walls of the small intestine, as a result of hypertrophy of the muscle. Cross-sections of a "normal" and of a thickened small intestine, at a distance of 1 metre from the pyloric sphincter, obtained at 13 weeks of age from calves given a milk substitute based on milk protein or one in which SCP supplied 44 percent of the protein, are shown in Figure 3. The cause of the thickening is not known, although factors that may be implicated are a greater bulk of indigestible material that has to be passed through the small intestine, quantitative and qualitative changes in the microflora of the alimentary tract, and an allergic reaction to the protein source. It is also not known whether the thickening of the intestinal walls would have any long-term effect once the calf has been weaned on to solid feed.

Conclusions. Many of the non-milk proteins so far tested as partial or complete replacements for the casein present in skim milk can cause digestive disorders, poor growth rates and mortality when used at high rates of substitution. When only 20 percent of the milk protein is replaced, protein digestibility in the young calf may be reduced although growth rate may not be markedly depressed.

In the neonatal calf the necessity for the diet to have good rennin-coagulation properties precludes the use of appreciable quantities of most non-milk proteins, unless a reduction in growth rate is acceptable. However, provided that toxic factors are extracted and any amino-acid deficiencies are rectified, the calf appears to adapt to lack of coagulation so that, by 3 to 4 weeks of age, between 20 and 40 percent of the dietary protein may safely be provided by many non-milk protein sources, and even 70 percent replacement is possible. ■

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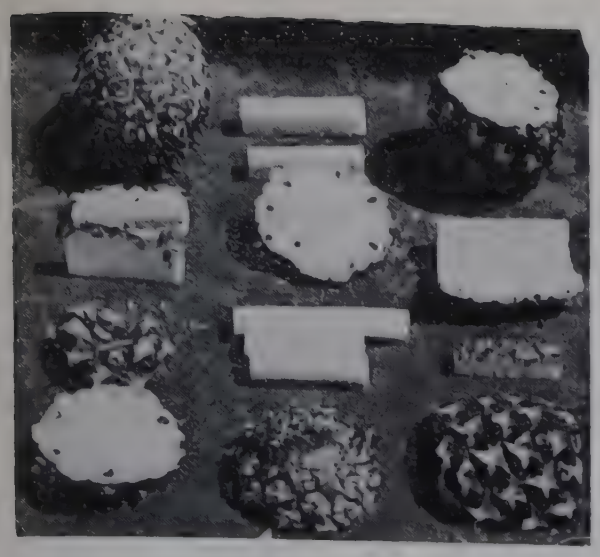

Over-ripe pineapple unsuitable for canning (*top left*) and other cut portions which are discarded as non-edible

Feeding potential of pineapple waste for cattle

Z.O. Müller

In many parts of the humid tropics, pineapples tend to grow on poor soils, often subject to tidal floods. One quarter of current pineapple production (4 million tons) is processed by canning industries which are usually situated near rivers and streams. These are used as vehicles for the disposal of factory wastes.

The largest pineapple producing countries of the world are the United States, Brazil, China (Taiwan Province), the Philippines and Malaysia.

As canneries can utilize only 15 to 25 percent of the fruit, the large volume of wastes creates serious pollution problems. For example, in Malaysia, about one thousand tons of pineapple cannery wastes are discarded daily, polluting adjacent rivers and the sea. This quantity of waste represents the equivalent, in terms of forage, of a feed supply for more than 20 000 head of cattle. In fact, the nutritive value of pineapple waste for cattle feeding is equivalent, on a dry matter (DM) basis, to cereal grain. When properly balanced, it ensures better performance than any tropical forage because it contains 65 to 74 percent total digestible nutrients (TDN) while tropical grasses or legumes usually fall well below 55 percent TDN.

There are two types of pineapple waste: cannery waste and plant res-

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Crosses of *Bos indicus* and exotic breeds fed on waste-based rations and averaging 54% dressing percentage

Photos: John Drysdale

TABLE 1. **Chemical composition of pineapple cannery waste (on DM basis)**

Type of cannery waste	Proportion of total fruit	Crude protein	Ether extract	Crude fibre	NFE [1]	Ash	Total sugars
			Percent				
Skin (shells)	56	6.4	0.92	16.7	71.88	4.1	42
Crown ends	17	7.2	0.82	25.4	62.88	3.7	38
Bud ends	15	7.0	0.84	22.3	65.76	4.1	40
Cores	5	7.1	0.96	19.7	69.94	2.3	73
Trimmings	2	6.8	0.91	16.2	73.49	2.6	74
Pomace	5	7.8	1.20	21.9	64.70	4.4	63

Source: Müller (1974).
[1] Nitrogen-free extract.

TABLE 2. **Average feeding value [1] of cannery waste and plant residues derived from pineapple fruit (on DM basis)**

Constituent	Unit	Cannery waste	Plant residue
Moisture	%	90.0	76.4
Crude protein	%	6.9	6.3
Ether extract	%	0.9	2.1
Crude fibre	%	17.8	23.6
NFE [2]	%	70.4	63.8
Ash	%	4.0	4.2
Digestible energy	Mcal/kg	3.26	2.57
Metabolizable energy	Mcal/kg	2.68	2.11
Net energy for maintenance	Mcal/kg	1.62	1.26
Net energy for gain	Mcal/kg	1.00	0.60
Net energy for lactating cow	Mcal/kg	1.76	1.28
TDN [3]	%	74	58

Source: Müller (1974, 1975).
[1] For cattle. — [2] Nitrogen-free extract. — [3] Total digestible nutrients.

TABLE 3. **Structural carbohydrate composition and in vitro digestibility of pineapple cannery waste in comparison with maize leaves**

Index	Pineapple cannery waste	Maize leaves
	Percent	
True dry matter digestibility	80.0	49.8
Cell wall (NDF) digestibility	72.6	33.0
NDF (CW) [1]	73.1	74.9
ADF [2]	37.0	48.3
Lignin	7.1	7.1

Source: Van Soest and Robertson (1976)
[1] Neutral detergent fibre (cell wall). — [2] Acid detergent fibre

idues. Pineapple cannery waste consists of the outer peel (shell), crown and bud ends of the fruit, fruit trimmings, the inner core and the pomace of the fruit from which juice has been extracted. The breakdown and chemical composition of these individual portions are given in Table 1.

The ratio of individual portions of pineapple cannery waste and their chemical composition varies considerably with the variety of the fruit, its ripeness, and the technology employed by the cannery. The quality of photosynthetic inputs (day and wave lengths) also have a great influence on the sugar content, reflected in the feeding value of the waste; for example, Hawaiian pineapples contain about 25 to 30 percent more sugar than Malaysian pineapples. The more juice that is extracted from pineapple cannery waste, the lower is its nutritive value, because soluble nutrients, sugars in particular, pass into the juice.

When energy was cheap, pineapple cannery waste was dried and the final product was called pineapple bran; excessive pineapple juice extracted from the cannery waste was usually evaporated into pineapple molasses, which was used either as a canning syrup or added to pineapple bran to increase its feed energy value. This practice is now being discontinued, not only because drying has become uneconomical (high capital and operating expenditure) but also because it degrades somewhat the original feeding value of the waste. The thermal process and the pelleting may result in the formation of amino-sugar complexes (Maillard reaction products) responsible for substantial losses in digestible protein.

The second type of pineapple waste is exemplified by pineapple leaves, a plant residue consisting of the upper part of the pineapple plant after the fruit has been harvested. It can be used as a good source of forage; when dried it is called pineapple hay, and when ground, pineapple leaf meal.

NUTRITIVE CONSTITUENTS OF PINEAPPLE WASTE

The chemical composition and feeding value of cannery waste and plant residues are nutritionally different, as shown in Table 2.

The nutritive value of pineapple cannery waste is high because the main constituents of organic matter are represented by soluble *carbohydrates*, mostly sugars. On the other hand, pineapple plant residues, like most tropical forages, have very few soluble carbohydrates and have excessive structural carbohydrates.

The sugars in cannery waste comprise about 70 percent sucrose, 20 percent glucose and 10 percent fructose. Apart from sugars, other carboydrates such as hemicellulose, cellulose, hexosans, pentosans and pectin

TABLE 4. **Digestibility of pineapple cannery waste for ruminants**

Constituents	Digestibility			
	Cattle	Sheep	Goat	Buffalo
	Percent			
Dry matter	72.5	71.7	71.7	74.2
Organic matter	73.3	72.1	72.5	74.6
Crude protein	39.9	40.9	39.6	47.4
Ether extract	27.8	19.4	32.1	30.1
Crude fibre	80.8	76.5	79.8	80.1
NFE [1]	74.8	73.8	73.9	76.0
Ash	58.2	61.3	53.3	67.9

Source: Hong (1973).
[1] Nitrogen-free extract.

TABLE 5. **Feeding of fresh pineapple cannery waste to ruminants** [1]

Country	Year	Species and/or class of ruminants	Live weight of animals successfully fed pineapple cannery waste	Level of forage substitution
			Kg	%
Hawaii, USA	1905	Dairy cattle	520	30
Hawaii, USA	1931	Beef cattle	280	30
Hawaii, USA	1946	Dairy cattle	510	50
East Africa	1955	Beef cattle	260	—
South Africa	1961	Dairy cattle	470	55
China (Taiwan Province)	1963	Dairy cattle	450	67
Congo	1965	Beef cattle	220	48
Zululand	1966	Beef cattle	240	69
Malaysia	1973	Dairy cattle	340	92
		Heifers	68	95
		Beef cattle	136	88
		Buffaloes	273	100
		Goats	27.5	100
		Sheep	20.5	100
Singapore	1974	Buffaloes in milk	640	95
Philippines	1975	Beef cattle	330	85
Malaysia	1977	Beef cattle	200	100

Source: Asia Research (1976 - unpublished).
[1] Surveyed mostly from unpublished reports or personal communications and visits.

are present. Pectin is a substance of high molecular weight and related to carbohydrates. Its presence in cannery waste is important because of its protective action in coating gastro-intestinal mucosa; it also acts as an absorbent in counteracting the bacterial toxins of enteritis.

Ether extract is represented in pineapple cannery waste by sterols and plant pigments comprising mostly carotenes and xanthophylls. The actual fat level is below 40 percent of the total ether extract.

The main constituents of *organic acids* in fresh cannery wastes are citric and malic acid; small quantities of oxalic acid are also present. Within 24 hours of storing cannery waste in the open air rapid changes take place, and a large volume of lactic acid is formed from monosaccharides and sucrose. If storage in the open air continues, lactates can be rapidly converted into butyrates which adversely affect the palatability and nutritive value of cannery waste. Butyrates are fortunately formed only on the surface of stored pineapples where oxygen is present.

Crude fibre of cannery waste varies from 11 to 24 percent. Much depends upon the variety, stage of ripeness and degree of juice extraction. The level of crude fibre could be a serious limiting factor for monogastric animals but not for ruminants, because cattle digestibility of crude fibre in cannery waste is surprisingly high compared, for example, with maize crop residue having a similar lignin content (see Table 3).

Protein and amino acid compostion in cannery waste becomes more important when the waste represents a substantial part of the feeding ration. Amino acid patterns indicate low biological value of the protein for monogastric animals.

Extensive *digestibility* studies with fresh cannery waste were carried out in ruminants by the Central Animal Husbandry Station in Kluang, Malaysia. They indicated that all ruminant species exhibit high digestibility coefficients for nutrients contained in this waste. The results are shown in Table 4. It is important to note that all ruminant species showed an unusually high crude fibre digestibility as well as a high digestibility of nitrogen-free extract. The latter demonstrates that cannery waste, when properly supplemented, is far superior to tropical forages of the highest quality.

As for *vitamins*, pineapple cannery waste contains a substantial level of biologically active A provitamins with a calculated vitamin A activity of 80 000 I.U. (on DM basis). This has also been shown by analyses of vitamin A and its provitamins in the blood and liver of cattle fed pineapple cannery waste as a sole forage (Müller, 1974). The vitamin E level in cannery

waste is, however, not sufficient to meet the requirements for cattle. The vitamin composition of pineapple leaf meal shows a content similar to that found in most dried tropical forages.

The *mineral composition* of pineapple cannery waste is to a large extent subject to the geological origin of the soils on which the pineapples are grown, the level and nature of the fertilizers used, the variety, its ripeness and other factors. Analyses of the mineral content of Malaysian cannery waste showed that it is poor in all inorganic constituents and must therefore be appropriately supplemented.

FEEDING CANNERY WASTE TO CATTLE

Pineapple cannery waste has been used as an occasional forage substitute since 1905. As knowledge of its value has gradually increased, cannery waste has been incorporated in cattle rations at a much higher level than before. A survey of some field data and experiments is given in Table 5.

From recent studies conducted in Malaysia, Singapore and the Philippines, it is obvious that ruminant rations can be based almost entirely on pineapple waste if limiting nutrients are balanced with care. However, the feeding of pineapple cannery waste alone would, in the long run, hamper the productivity and health of animals. Although ruminants accept cannery waste very well and the adaptation period of cattle fed previously on green forage lasts only a few days, it is necessary to watch the balance of nutrients and the moisture content of the diets based on pineapple cannery waste.

The usual moisture content of cannery waste is about 90 percent, but it could be lowered to 80 percent by pressing. Pressing has the advantage that the weight of the waste is reduced by one half during the process. Supplementary feeds for diets based on pineapple cannery waste should be chosen with a view to reducing the moisture content of the total ration still further (to 50 to 60 percent), to supply all limiting nutrients such as protein, minerals and vitamins, and to alter the acidity of the total ration.

Because pineapple wastes are accumulated daily in large quantities in every cannery and are usually available the whole year round (with some seasonal fluctuations in the harvest), they can be utilized as feed for cattle on a commercial basis. Under proper management, such an enterprise can have many economic advantages compared with cattle feeding systems using forage and other traditional feed resources, as has been demonstrated in Malaysia.

TABLE 6. **Composition of silages based on pineapple cannery waste and poultry litter (DM basis)**

Constituents	Tested silages		
	A	B	C
	. . . *Percent* . . .		
Chemical composition			
Moisture	49.3	45.4	47.2
Crude protein	13.4	14.3	14.1
Ammoniacal nitrogen	0.4	0.4	0.3
pH value	4 .5	4.7	4.5
Acetic acid	1.3	1.3	1.1
Butyric acid	0.9	0.7	0.7
Lactic acid	3.9	4.2	3.7
Acid value (mg KOH)	18.3	15.2	14.7
TDN value [1]	72.0	70.0	72.0
	. . . *Percent* . . .		
Ration composition			
Pineapple cannery waste	60.0	47.5	52.0
Poultry litter (broilers)	25.0	33.0	27.0
Oil palm waste (fibres)	—	10.0	6.0
Fermentation industry waste (glutamic acid)	2.0	1.0	2.0
Bakery waste/ molasses [2]	11.0	6.5	11.0
Supplement	2.0	2.0	2.0

Source: Asia Research (1976 - unpublished).

[1] Total digestible nutrients. — [2] Or other locally available waste containing above 82% TDN (on DM basis).

MALAYSIAN WASTE RECYCLING PROJECT

This project (Asia Research, 1976) was designed to accommodate 2 000 head of Malaysian crossbred cattle on an area of 3.5 ha. It has a feeding system involving the processing of pineapple waste together with cattle and poultry manure and other wastes and by-products into a wholesome and palatable diet. Wastes and industrial by-products comprise 96 to 98 percent of the total ration; only 2 to 4 percent of the ration consists of supplements and additives. No traditional forages or feeds are used.

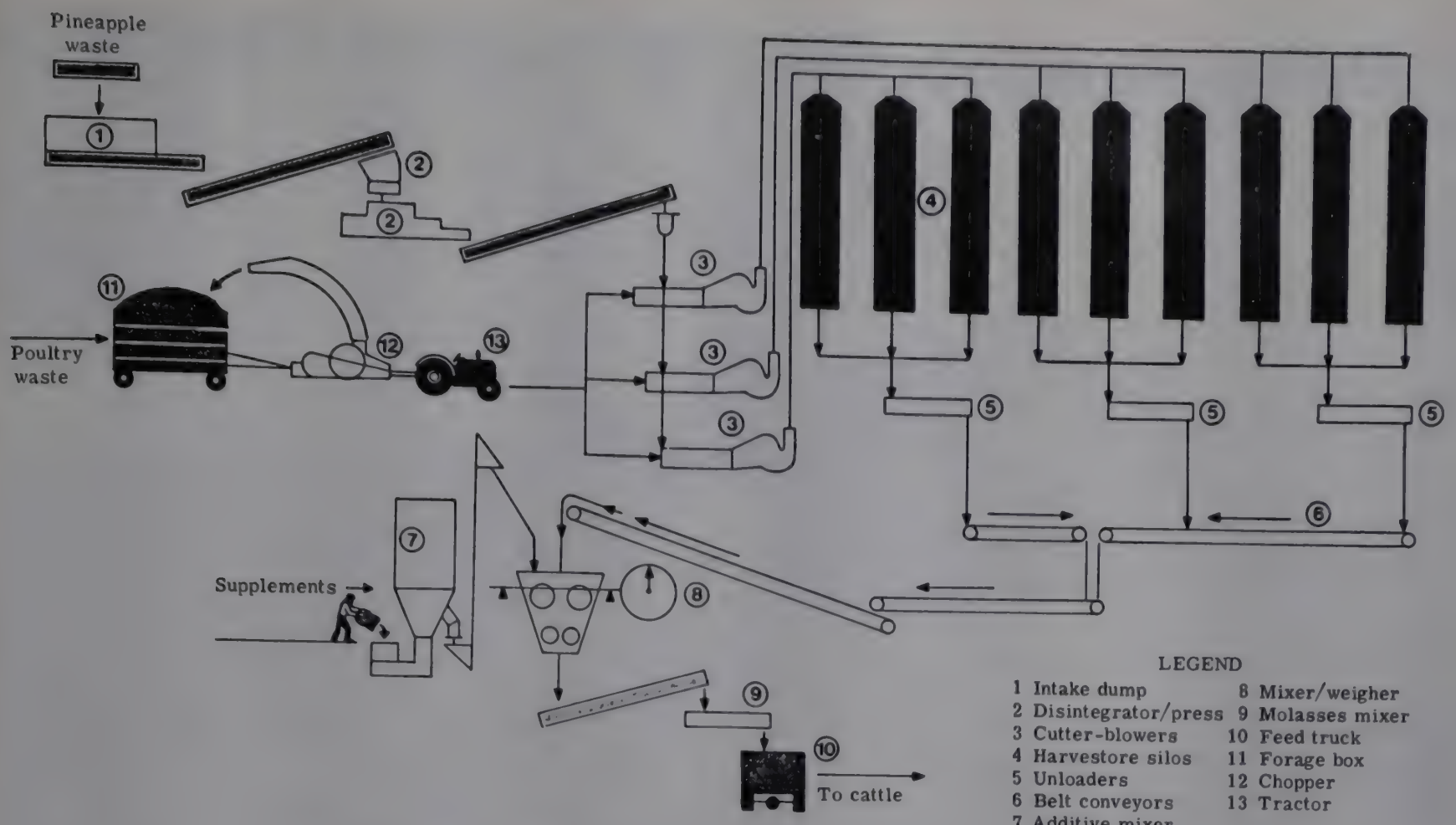
The wastes are either processed in hermetically sealed silos or subjected to chemical treatment. Both processes increase palatability, reduce acidity, and reduce the bacterial count well below minimum safety requirements.

The ensiling process consists of an input of raw materials which, in the case of pineapple waste, must first be crushed or shredded and, in the case of poultry waste, sieved. These materials are then conveyed in predetermined proportions to a mechanical, horizontal mixer. After mixing, the material is elevated mechanically to the top of a silo which is then sealed. The self-generating fermentation process lasts about 10 days. The finished product is either transported directly to feed troughs by a forage box, or, when the product needs to be fortified by supplements and additives, a feeder mixer is used. The schematic flow of the process is shown in Figure 1.

This method of processing wastes (livestock wastes [1] in particular) is safer than conventional drying methods as it eliminates nematode parasites (occurring in cattle manure), rendering the feed harmless to animals and human beings. It is by far the most effective system from both the economic and health points of view.

The quality of the silage, based on pineapple cannery waste and poultry

[1] The term "livestock wastes" used in this article refers to various kinds of poultry litter, poultry manure, cattle manure and feedlot wastes from different waste management systems, e.g., slatted or concrete floor, paved or unpaved yards, manure with or without bedding, etc.



Schematic flow sheet for the processing of pineapple waste as animal feed

manure, is high because the initial acidity and the presence of sugars ensure optimum fermentation. Pineapple waste-based silage is therefore more palatable, screening odours and other negative properties of poultry manure. The analytical data of three such silages are shown in Table 6. On average, they contain 14 percent crude protein, 70 to 72 percent TDN, and are well balanced in minerals and vitamins. The feed intake per head per day of such silages (at an average liveweight of 200 kg) is 8 to 10 kg (on a DM basis) or 4 to 5 percent calculated on the basis of the liveweight of the cattle. The key element in the feeding system is the use of wastes and manures with different nutritive properties, so that the combinations meet most of the nutrients required in the complete ration. The supplements and additives that are incorporated are intended to fortify the basic feed so as to ensure optimum performance.

The economics of the feeding system is self-explanatory: feed overheads per kg of liveweight gain vary from U.S.$0.18 to 0.22; the total cost of 1 kg of liveweight gain (including transport, labour, other operating costs, depreciation and interest) is between U.S.$0.40 and 0.50. Feeder cattle are purchased at U.S.$0.90 per kg liveweight and finished cattle sold at U.S.$0.95, giving a reasonable profit margin. The capital outlay is U.S.$400 000 in fixed assets (including land) for the feedlot, which accommodates 2 000 head of cattle.

The reason for such an unusually high profit margin is that traditional forages, grains and other feed concentrates are substituted by abandoned waste resources of zero or low commercial value. While most tropical forages are low in nutritive value, and grains or feed concentrates are too expensive, some wastes, on the other hand, have a high nutritive value and are available at low or no cost, other than the cost of transport. Moreover, grain and feed concentrates are more effectively utilized by monogastric animals and are, of course, directly used for human nutrition after being processed.

The feeding system based on pineapple waste described here can also be applied to breeding cattle and to dairy cows, a development upon which the Malaysian project is currently embarking. ■

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Dairy development in India - Part II

Mogens Jul

The first part of this article (published in World Animal Review 24) dealt with the origins of the "Operation Flood" project, its current status, its nutritional implications, and the effect that it has had on increasing self-reliance and social development in India. The second part published here is concerned with milk distribution, city cattle-keeping, economics and resources, as well as the lessons to be learnt from the project.

MILK DISTRIBUTION

In dairy development in many parts of the world insufficient attention is paid to the crucial subject of milk distribution. In some cases dairy project originators seem to be motivated primarily by a desire to secure an adequate milk supply and to assume that its distribution and sale will be automatic. It is therefore gratifying to see that in the Operation Flood project one of the major thrusts has been in the direction of improving milk distribution and designing new systems for this purpose.

Bottling. The classical form of "modern" milk distribution is bottling. Milk supplies in the existing dairy schemes in the four cities of the project area (Bombay, Calcutta, Delhi and Madras) are based on bottling. The project has accepted that bottling should continue and also that bottling capacities in certain cases should be increased.

However, it is also realized that bottling is, in some situations, an obsolete distribution method designed before acceptable alternatives were available. Many are fascinated by the fact that bottles can be returned and re-used, considering this a resource-saving device; but, when the total system is considered, the added expenditure of transporting the heavy bottles and returning them, the work involved in cleaning them, the resulting breakages and so on can well make this distribution system more wasteful of resources than other systems. Also, the effluent from the bottle cleaning operations is a rather heavy load on city sewage disposal systems.

Another objection to bottling is that it normally requires a cash deposit from the customer for each bottle. For low-income families this is an added outlay which may frequently discourage a potential buyer. Many cases are known in India where the bottles are emptied into the customer's own receptacle on the sales premises to avoid the payment of a deposit. Also, milk adulteration is feared, and it is not infrequent to learn of cases where the sealed caps on the milk bottles have been tampered with and the milk adulterated.

Cans. When one is dealing with low-income societies, it is frequently suggested that milk might be distributed out of cans. Such an operation has been successfully undertaken in the town of Anand, for instance, where all milk is distributed in this way to a population of some 70 000. However, in other places there seems to be a considerable resistance to this kind of distribution, and it is felt that it should not be used in a modern milk scheme. One objection is that adulteration is difficult to control.

Plastic sachets. In Bombay, Ludhiana and Madras equipment is being used for packaging fresh milk in plastic pouches, which seem to meet with considerable consumer acceptance (one advantage is that no returns and deposits are needed). Objections have been made on the grounds that the system may be resource consuming; however, the resources used for the plastic pouches are basically not in excess of those required for transporting and cleaning bottles. In addition, considerable local use is known to be made of the plastic pouches once emptied.

Aseptically packaged milk. Where one-way containers are used, attention

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Milking buffaloes in the streets of Madras. One of the objectives of the "Operation Flood" project is to eliminate the keeping of buffaloes and cattle within the city. In the view of the author this practice is likely to be phased out once the organized milk supply systems from rural areas have been proved capable of supplying cheaper milk of better quality — in sufficient quantity — to the cities.

needs to be given to the advantages of aseptically packaged milk. Such milk can be packed in one-way containers even at the rural dairy and transported without the use of refrigeration. A systems study suggests that this may well be the least resource-requiring means of packaged milk distribution, especially suited for Indian conditions, where refrigeration of milk at the retail level is an exception rather than a rule.

Automatic bulk vending. One remarkable part of the project is the development of automatic bulk vending systems. These are so designed that the consumer can go to a booth which is conveniently located and operated by a concessionaire. The customers bring their own receptacles, which are placed under a spout. They put a coin or token into a slot, and half a litre of milk pours into the receptacle. Some 150 booths of this kind are in operation in Delhi, and they are currently dispensing a total of some 100 000 litres of milk per day.

This system was developed by the National Dairy Development Board (NDDB) and the Indian Dairy Corporation (IDC), and they received for it an Indian award for import substitution, all the machinery and equipment being of Indian manufacture. The use of such a milk distribution system is well suited to Indian conditions, since Indian customers are used to bringing their own receptacles to the private vendor. This system is fairly well protected against adulteration but it does need careful management, in that each booth has a refrigerated milk tank which needs to be emptied and cleaned once a day. However, Indian experience with this type of distribution seems to be entirely satisfactory.

Choice of milk distribution systems

It is obvious that a project as large as Operation Flood could not rely entirely on one particular milk distribution system. On the contrary, the IDC puts major emphasis on developing many different systems with the aim of achieving maximum milk distribution.

CITY CATTLE-KEEPING

Hygiene and genetic loss. One objective of the project is to eliminate city cattle-keeping since this practice

is considered unhygienic. Besides, it was felt that many high-yielding animals are taken to the cities only to be slaughtered after one lactation period. The calves are often sent with the dams to secure the necessary milk let-down effect, and since the calves are seldom properly looked after they are mostly lost to the dairy industry.

It appears, however, that practices may have changed considerably. High-yielding cows and buffaloes are expensive animals; more often than not, when they go dry they are now sent to the rural areas for freshening, and may be returned to the city after the next calving. Moreover, only a few calves are currently sent with the dams to the cities. Thus, the loss of genetic material may not be as significant now as in earlier years.

City cattle-keeping is undesirable from a hygienic point of view, but so is the widespread practice of keeping cattle very close to human dwellings in every town or village. A hygienic problem exists in the bacteriological quality of city-produced milk which is rarely pasteurized and is sold directly to the consumer. The inherent danger in this is offset partly by the fact that most milk is boiled prior to consumption; in fact, there is a general taste preference for boiled milk in India.

Resettling city cattle. In the original project some funds were set aside for helping city cattle-keepers resettle in the country but this scheme overlooked the important fact that a city cattle-keeper is mainly a marketeer. His asset is not his milk production but the established trade with a regular clientele. Most of the operators of city-kept cattle have adequate means and are not likely to be interested in settling in a rural area where they would obtain much lower prices for their milk. It is true, of course, that production prices would also be lower, but the prospect of becoming rural milk producers is hardly likely to tempt city cattle-keepers. These operators will probably turn to other trades once the organized milk systems have become firmly established and have achieved the objective of "flooding" the market.

Selling cattle feed at milk collection point in Gujarat. The future of dairying in India depends to a large extent on the use of appropriate feed materials in such a way that milk will continue to be an added food resource — and that its production will not be detrimental to total food supplies.

TABLE 1. **Annual milk production and net income in India**

	Milk production	Net income [1]
	Litres	*Rs.*
Indigenous cow on current feeding	200	175
Indigenous cow on improved feed	475	700
Crossbred cow on cultivated green fodder and concentrate feed	2 500	1 300

[1] Excluding labour.

TABLE 2. **Net annual food caloric balance of cow milk production in India**

	Input	Output	Balance
		Mcal	
Indigenous cow fed on agricultural waste in addition to wayside grazing	0	135	135
Indigenous cow 1 kg concentrate feed/day during lactation in addition to wayside grazing, etc.	200	318	118
Crossbred cow 600 kg concentrate feed annually and crop from 1/6 ha land	1 000 and [1] 2 800	1 350	—2 450

[1] Potential food production from 1/6 ha of land

TABLE 3. **Actual net income and net food production per year over the lifetime of a cow or buffalo under project area conditions**

Animal and management	Milk production	Net income from milk	Food calorie yield from milk	Potential food calories in feed or from land devoted to fodder		Net food calorie yield
				Feed	Land	
	Litres	*Rs.*	..... *Mcal*			
Indigenous cow — no supplementary fodder or feed	200	175	135	—	—	135
Indigenous cow — 150 kg supplementary feed and fodder from 0.04 ha	475	413	320	62	875	−617
Crossbred cow — 450 kg supplementary feed and fodder from 0.04 ha	1 800	1 500	810	186	875	−251
Buffalo — no supplementary fodder or feed	450	900	526	—	—	526
Buffalo — 250 kg supplementary feed and fodder from 0.04 ha	700	1 150	800	82	875	−157
Buffalo — 1 350 kg supplementary feed and fodder from 0.08 ha	2 500	1 800	2 625	557	1 750	318

Small-scale dairy supply manufacturing industry in Anand, Gujarat. In addition to other benefits, "Operation Flood" has also provided a stimulus to industry.

In late 1975 restrictions were placed on city cattle-keeping in Bombay and Delhi. This has not caused the cattle-keepers to settle in rural areas, but rather in other areas of the city or in its immediate vicinity. They continue to base their milk production on purchased fodder and feeds, so that their production prices remain relatively high. This is offset by the relatively high price which they are able to obtain from their established clientele. It was very revealing that displaced city cattle-keepers in Delhi complained about the burden of transport of their milk from their new stables to their usual areas of sale; this confirmed the fact that their main asset is their established trade.

It is the view of the author that the practice of city cattle-keeping is likely to be phased out once the organized milk supply systems from the rural areas have been proved capable of supplying cheaper milk of better quality and in sufficient quantities to the cities. This has been the course of development in most dairy development programmes elsewhere, and it is likely to be the pattern which will be followed in India as well.

ECONOMICS AND RESOURCES

Improving dairy animals. India has a very low production per dairy animal compared to dairying in the industrialized world; often it is as low as 150 to 300 litres per year. It is understandable, therefore, that great efforts are being made to improve the milk yield of the dairy herd. This is done in two ways.

The milk yield of a dairy animal can be substantially improved by giving it better feed, especially during the lactation period; therefore, the provision of green fodder and/or concentrate feed is a significant component of the project. Secondly, some animals give much higher yields than others. It is well known that through careful selective breeding many developed countries have achieved high milk yields. Unfortunately, improving the Indian dairy cow through similar selective breeding would be very time-consuming. It may be better to in-

troduce western breeds, but they are not generally suited to Indian conditions; however, the experience with crossbreds between western and Indian breeds has been much more successful.

Thus one important part of the project is the introduction of crossbred cows. A programme of this kind is more likely to succeed for economic reasons as well than any effort to introduce completely new breeds. The latter would require that each dairy producer purchased or obtained by a loan an animal for which the capital outlay would be enormous. A more manageable approach is the improvement of the existing dairy herd by crossbreeding, with the use of artificial insemination. Therefore, maintenance of a breeding herd and artificial insemination are important parts of the project, and much effort also goes into the installation of semen freezing facilities.

Economics. Table 1 summarizes the potential of the project. By providing an indigenous cow with improved feed during the lactation period, it should be possible to increase its milk yield from about 200 to 475 litres per year. However, using a crossbred cow and giving it green fodder and concentrate feed may increase milk yields to as much as 2 500 litres per year. The latter, of course, means added expense, but the effect on net income per animal is substantial. Income could increase from Rs. 175[1] per indigenous cow per year under current feeding practices to Rs. 700 for a well-fed indigenous cow, and Rs. 1 300 for a well-fed crossbred animal.

For buffaloes the situation is somewhat different because there is no possibility of obtaining quick results through crossbreeding. A programme of selective breeding is under way but can have only a long-term effect. The main emphasis is therefore on increasing milk yield through more efficient feeding and on improved management.

Effect on food supplies. In all of this, however, one must consider also the overall effect of any proposed policy on food supplies.

[1] Rs. 8.50 = U.S.$1.00

For instance, it has been advocated that about 1/6 ha of land should be devoted to fodder production to feed each crossbred cow. But such land might be capable of producing substantial amounts of food grain (wheat and rice). Furthermore, concentrate feeds used for cattle may contain a cereal or other component that could be used or processed into edible products for humans. Table 2 summarizes the effect of an unrestrained effort to introduce western-style dairying into India. An indigenous cow feeds only on wayside grazing and agricultural wastes; thus it consumes no products directly usable by man, and its total milk yield is an added food resource. An indigenous cow given additional feed will, to a certain extent, consume materials that may be suitable for direct human consumption. Yet the total outcome is a positive contribution to the Indian food supply, especially when one considers that milk is a higher-grade food than the component parts of the feed concentrate. However, where intensive feeding of crossbreds takes place, the agricultural crop (which may not be produced because of the need for fodder production) and the food part of the feed concentrate may constitute such large amounts of potential foods that the total balance is negative, quite seriously so. In fact, for each intensively reared crossbred cow about 2 million kcal of food may be lost per year — enough for the annual food supply of two persons. Obviously such developments should not be permitted to take place.

Thus a danger could exist that the introduction of western-style dairying practices could seriously exacerbate India's already precarious food situation. But, in reality, the performance of present-day dairying in India suggests that the danger is not imminent.

Table 3 has been worked out on the basis of actual performance data obtained by the IDC. It suggests that only in a few cases does a negative food supply balance develop. Even here, this is on the assumption that all land used for fodder production could be used for food crops, and that all cereal and oil cake utilized for feed could be used as food for humans. However, fodder may well be grown on land or in seasons where no food crop cultivation is possible. Also, it would take a great deal of effort before oil cakes could be upgraded to human food, while some of the oil cakes produced from waste oilseeds cannot be upgraded anyway.

It may be useful to look at the actual performance in food production. Table 4 shows the development of agriculture in the state of Gujarat, where dairy development has been most intensive. In spite of a rapidly growing milk collection programme, the production of grain crops has more than doubled, and the production of other agricultural crops has also experienced similar development. Thus, if a danger might exist of an undesirable effect on food production eventually, the effect so far has been the opposite, and development has, in fact, been very encouraging. One important factor is that in the project area much use has been made of natural pastures and waste land for fodder production.

TABLE 4. **Agricultural development in Gujarat**

Year	Total grain crops	Total other crops	Milk collection
	..... *1 000 tons*		
1955/56			11
1956/57			14
1957/58			21
1958/59	177	83	28
1959/60	145	90	23
1960/61	137	94	24
1961/62	188	77	35
1962/63	184	98	50
1963/64	205	132	62
1964/65	216	73	61
1965/66	215	73	66
1966/67	262	106	72
1967/68	317	141	81
1968/69	233	105	113
1969/70	414	171	124
1970/71			118
1971/72			133
1972/73			148
1973/74			112
1974/75			130

Source: NDDB (1976), personal communication.

The total area devoted to fodder production is as yet small in India: about 4 percent of the total arable land, compared with 25 percent in the United Kingdom and 60 percent in the United States. In addition, much of the land utilized for fodder production in India was previously waste land or communal lands with a low degree of utilization due to overtion from the NDDB, it is possible to grow fodder crops along with food crops: maize and lobia; sugarcane and berseem; jowar and cowpea; jowar and guar; fruit trees and fodder; and vegetables (on ridges) and fodder (below ridges). The fodder crop may be harvested before the food crop or utilized by some other means simultaneously with the latter.

TABLE 5. **Cropping pattern in India**

Region	Kharif (June-Oct.) grain crop	Lean period (Oct.-Nov.) catch crop	Rabi (Nov.-Apr.) grain crop	Lean period (Apr.-June) catch crop
Anand (Gujarat)	Bajra	Cowpea/mustard	Wheat	Cowpea
	Paddy	Cowpea/mustard	Wheat	Cowpea
	Tobacco			Bajra + cowpea
Hissar (Haryana)	Maize	Cowpea/mustard	Wheat	Bajra + cowpea
	Bajra	Turnip	Wheat	Jowar + cowpea
		Cowpea/mustard		
	Jowar	Turnip/mustard	Wheat	Maize + cowpea
Kanke (Bihar)	Maize	Cowpea/mustard	Wheat	Maize + cowpea
	Paddy	Cowpea/mustard	Wheat	Bajra + cowpea
Patna (Bihar)	Paddy	Cowpea/mustard	Wheat	Maize + cowpea or maize
Kalyani (West Bengal)	Paddy	Turnip/mustard	Wheat	Cowpea + bajra or maize + cowpea
Jabalpur (Madhya Pradesh)	Maize	Cowpea/mustard	Wheat	Maize
	Paddy	Cowpea/mustard	Wheat	Jowar
	Soybean	Cowpea/mustard	Wheat	Cowpea
Jhansi (Uttar Pradesh)	Jowar	Turnip/cowpea	Wheat	Maize + cowpea or jowar + cowpea or bajra + cowpea
Hyderabad (Andhra Pradesh)	Paddy	Cowpea/mustard	Wheat	M.P. Chari (sorghum)
	Maize	Cowpea/mustard	Wheat	M.P. Chari (sorghum)
Poona (Maharashtra)	Bajra	Turnip/mustard	Gram	Maize
	Bajra	Cowpea/mustard	Wheat	Jowar + guar (sorghum) + (cluster bean)
	Sugarcane			Maize + cowpea

Source: Report of the Indian Grassland and Fodder Research Institute, Jhansi (1975) on forage production and feeding systems.

grazing, or fallow land. In many situations fodder production is actually a useful means of soil conservation. The use of communal lands for food crops would often be in conflict with existing laws, so that dairying may actually be the only effective means of using this resource.

Alternative production systems. Another important development has been the introduction of intercropping. As indicated in a personal communica-

Most important, however, is the fact that most of India is favoured by having a twelve-month growing season which, especially where irrigation is available, can be used to advantage in growing several crops a year. Of these, the maximum number of food crops would be two, and there would still remain some short seasons where the soil is available for fodder crops. Table 5 suggests cropping patterns for various areas of India where food crops and fodder crops are grown successively on the same land. This practice, of course, requires more labour but is quite remunerative; thus, where a single crop may yield an average annual net income per ha of Rs. 400-900, the use of jowar and cowpeas or maize and cowpeas in rotation may, for instance, increase the income to Rs. 1 200. In addition, in cases where a leguminous crop can be used, a fodder crop may help in increasing the fertility of the soil. Much evidence is available to suggest that such practices are actually gaining acceptance.

Other measures are also available. Thus, efforts have been devoted to developing dual purpose crops, i.e., hybrid varieties of maize, jowar and bajra. In these cases, the stalks and leaves of the plants will remain green when the grains are ripe for harvesting; thus the plant itself forms a useful fodder resource for animals.

For the small farmer and the landless farm labourer, the chances are high that their milk production is based mainly on materials that are not otherwise usable as human food. Table 6 shows the conventional feeding patterns in the Kaira District of Gujarat.

Other solutions. Many other possibilities are being explored. Studies are being undertaken to determine the extent to which cattle and buffaloes can be improved by selective breeding and, where applicable, by crossbreeding, and still retain their ability to produce milk mainly on feeds which could not be used for human consumption. Programmes are also being undertaken to increase the use of agricultural wastes for feed purposes. It is likely that many products now wasted or used for crude industrial purposes could be converted into materials which could be digested by ruminants. Relevant also is the study of the use of urea and other non-protein sources in the feeding of dairy animals.

FUTURE

The future of India's dairy production depends on the intelligent planning of agricultural practices and on

TABLE 6. **Conventional feeding patterns of milch animals**

Milk producers and nutrients	Quantity	Dry matter
	. Kg (per animal per day) .	
Landless		
Green fodder consisting of harvested herbage and wayside grazing, etc.	10.00	2.00
Dry fodder consisting mainly of farm residues obtained mostly as payments in kind for work on other farmers' fields	7.50	6.75
Concentrate mixture consisting of groundnut cake, cotton seed, bran and crushed/damaged bajra grains	2.00	1.80
Total		10.55
Small farmers		
Green fodder (home grown) and harvested herbage and wayside grazing, etc.	12.00	2.40
Dry fodder consisting mainly of farm residues	7.00	6.30
Concentrate mixture consisting of groundnut cake, cotton seed, bran and crushed/damaged bajra grains	2.30	2.07
Total		10.77
Medium and large farmers		
Green fodder (home grown)	16.00	3.20
Dry fodder consisting mainly of farm residues	7.00	6.30
Concentrate mixture consisting of groundnut cake, cotton seed, bran and crushed/damaged bajra grains	2.50	2.25
Total		11.75

Source: N.R. Tumkur (1975), personal communication.

the use of appropriate feed material, in such a way that milk production may continue to be an added food resource and not a food which is produced to the detriment of total food supplies.

LESSONS FROM THE PROJECT

When assessing the lessons learned from the project for dairy development in other areas or countries, it must be borne in mind that, among low-income countries, India is in a special situation in having a large reservoir of well-trained personnel. Even so, this project has been a success because painstaking attention was paid to details and to intelligent planning. Most of the problems encountered were of an intricate nature; a deep understanding of the complexities was necessary to bring the project to completion. The IDC and the NDDB have been unusually skilful in these respects.

STAFFING BY NATIONALS

The author is convinced that the main reason for the success of this project is that it is staffed by nationals. They combine a high degree of technical competence with complete familiarity with the Indian scene. They identify themselves with the project, feel personally involved and accountable, work in unison and guarantee continuity for the simple reason that their own future depends on the success of the project.

In few other countries could this situation be duplicated; however, it is likely that similar projects will be initiated in several other parts of India, so it is important that this opportunity be utilized to the maximum. The World Bank has already given support to three such projects in India.

TRANSFER OF VALUABLE TECHNICAL ASSISTANCE

This project also shows that India has a large number of persons well trained in dairy technology, dairy cattle husbandry, milk marketing, etc. It is likely that India would be capable of rendering valuable technical assistance to other countries in these fields.

Because of the traditional use of milk as a weaning food and a food for children, it is often thought desirable to establish milk-supply systems in low-income countries in order to improve nutrition by making milk available to low-income groups. But because of the relatively high cost of production and distribution, milk is not a suitable food for such purposes. Not even in situations where subsidized food distribution is considered could milk be recommended.

The project has shown that milk production is a suitable occupation for low-income groups in rural areas, where the very poor are often so employed. When the milk is sold to middle- or high-income groups, a voluntary income redistribution takes place, leading to much improved conditions among the rural poor.

In dairy development attention needs to be paid to the danger of replacing food crops with feed crops or even using edible cereals as feed. However, a skilfully organized dairy system, capable of converting otherwise unused agricultural waste into a high-quality food, could form the basis for a remunerative occupation in rural areas.

Finally, surplus dairy products from the affluent countries are well suited for building up a dairy industry in a developing country. They can be used to supplement local milk supplies, can be fed into an expanding dairy system and easily phased out when the local supplies increase. ■

Vesicular diseases of swine

John H. Graves

Vesiculation of the coronet in early stages of FMD

The vesicular diseases of swine can have a significant impact on the cost of pork products to the consumer. Losses are due to both the damage done to the individual animal and the impact of trade restrictions imposed by importing countries. Although other livestock species are affected (see table below), swine is the only species susceptible to infection by all of the major vesicular disease viruses: foot-and-mouth disease (FMD), swine vesicular disease (SVD) and vesicular stomatitis (VS). Another disease, vesicular exanthema of swine (VES), now considered extinct as a disease, is often included in this group. The vesicular diseases are usually discussed together, as there are no clinical characteristics that permit them to be differentiated from each other without laboratory diagnostic support.

Clinical signs. Foot-and-mouth disease, SVD and VS in swine are characterized by the appearance of vesicles or blisters at one or more of the following sites: gums, lips, snout, and interdigital spaces and coronet of the feet.

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The vesicles are filled with a straw-coloured lymph-like fluid which is very high in virus content. As the disease progresses the vesicles rupture, leaving a raw, bleeding surface. Healing of the vesicular lesions is usually rapid unless there is infection of the lesion areas by bacteria.

Lameness and reluctance to move are often the first signs of vesicular disease in swine. Eating may be seriously curtailed in infected animals with extensive lesions of the mouth. Fever occurs during the development of lesions and may persist for up to a week. Loss of the hooves is a common aftermath of vesicular diseases in swine and regrowth may be distorted, resulting in chronic lameness.

Internal body organs may also be affected. Both FMD and SVD virus infections can cause myocarditis, which is believed to be the major cause of the high mortality in suckling swine and may be fatal in adult animals. Pancreatitis occurs from FMD virus infection of acinar cells. Diffuse encephalitis commonly occurs in SVD-infected swine four to seven days after infection (Monlux *et al.*, 1974). Involvement of organs other than the integument is not usually seen with VS virus infection.

High mortality is rarely associated with vesicular diseases in swine except in young animals. The major economic impact of the disease in adult swine results from loss of weight, mastitis, abortion and general unthriftiness which make raising the animal unprofitable.

Geographic distribution. Foot-and-mouth disease is the most widely distributed of the vesicular diseases. It occurs in all continents of the world except North America and Australia. The British Isles, Scandinavia, Japan, New Zealand and the islands of the Caribbean and Oceania are also free of the disease. The problem is magnified by the presence of seven distinct immunological types of the virus which vary in worldwide distribution. An animal recovered from infection by one virus type is fully susceptible to reinfection by another virus type. As many as five immunological types of FMD virus are endemic in some areas of

Vesicles of teat and udder in early stages of FMD

Africa. India has to contend with four virus types, while most of South America and Europe have only three immunological types.

Swine vesicular disease has occurred in most of the countries of Europe, including the U.K., as well as in Hong Kong, Japan and China (Taiwan). It is a relatively new vesicular disease of swine, having first appeared in Italy in 1966 (Nardelli *et al.*, 1968). The virus of SVD is serologically and physically closely related to a common enteric virus of humans. It has been proposed that it is a new disease of swine that originated by mutation from a human virus (Graves, 1973). A common problem in the control of SVD is the occurrence of subclinical infection which hinders the identification of infected herds.

Vesicular stomatitis is a disease of the western hemisphere. It is endemic in the coastal areas extending from the southeastern United States through Mexico, Central America, and the northern coastal countries of South America. Epidemics have occurred as far north as Canada and as far south as Argentina. There are two distinct serotypes of VS virus which, like FMD, allow reinfection of an animal recovered from one type by the second type.

The endemic presence of any of the vesicular diseases demands constant laboratory monitoring to determine that a new vesicular disease has not entered the country. Because of the very similar clinical appearances, it is dangerous to assume that a vesicular disease outbreak in swine is due to an indigenous vesicular disease virus.

Spread of vescicular diseases. Foot-and-mouth disease and SVD are spread by contact of susceptible animals with infected animals or with materials contaminated by or originating from infected animals. Swine are often involved in transmission of these diseases because they may be fed garbage containing scraps from animals slaughtered during infection. Many countries have regulations that make it mandatory for garbage to be thoroughly cooked before it is fed to swine; however, these regulations are difficult to enforce. Garbage not only spreads these diseases within countries but has introduced them into previously disease-free countries by means of garbage from aircraft or ships originating in infected countries. The severe and costly outbreak of FMD in the U.K. during 1966 started in swine that were fed garbage which apparently contained scraps of meat from South American imports. The spread of SVD throughout Europe and into Japan was by international movement of pork from infected animals. The virus of SVD is very stable and can remain viable for a long time in processed pork products. McKercher *et al.* (1974) found that SVD virus in sausages prepared from meat of infected swine was capable of infecting susceptible swine when the sausages were fed to them even 500 days after their preparation.

Foot-and-mouth disease and SVD are readily transmitted by contact of susceptible and infected swine. The most infectious period is the 24-hour interval prior to the appearance of clinical signs of disease. This means that many apparently normal animals in a herd may be in the incubation stage of the disease when the first clinical cases are observed. Contact of susceptible swine with virus-contaminated surroundings such as holding pens or vehicles used to transport diseased animals is a means of initiating new infections.

The natural transmission of VS from animal to animal is not clearly established. The disease can be transmitted to susceptible swine by contact with virus-contaminated saliva from infected swine once the disease is established in a swine herd. There are strong indications that VS virus may be transmitted by biting insects; the disease is seasonal, it disappears after the first frost, and its spread is dependent upon the same climatic conditions which foster flying insect development.

Diagnosis. Accurate differential diagnosis to determine which virus is the cause of an outbreak of vesicular disease in swine is important to the development of appropriate disease control procedures. As already noted, these diseases in swine are clinically indistinguishable from one another, and it is necessary that appropriate samples of the vesicular lesion epithelium and fluids be submitted for laboratory diagnosis. The most rapid and commonly used laboratory test to differentiate these diseases is complement fixation using infected lesion material as antigen, with antisera specific for each of the types of each vesicular disease virus. Many countries have state and national laboratories that perform such tests. International vesicular diagnostic centres are located at Pirbright, U.K., and Rio de Janeiro, Brazil. The World Reference Centre for Vesicular Diseases at Pirbright is responsible for the definitive classification of the types and subtypes of FMD viruses.

The absence of disease in some species during a vesicular disease outbreak cannot be used to differentiate the causative agent. Brooksby (1950) found an FMD virus recovered from swine that was only mildly infective to cattle. This seems to imply that the listing in the table above relates to types and subtypes of viruses infective for each species.

Susceptibility of livestock to the major vesicular diseases

Species	Foot-and-mouth disease	Swine vesicular disease	Vesicular stomatitis
Swine	++	++	++
Cattle	++	—	++
Sheep	++	—	++
Goats	++	—	++
Horses	—	—	++

++ Susceptible to natural infection. — Non-susceptible to natural infection.

Control. Successful control of vesicular diseases requires consideration of the fundamental aspects of the disease to be controlled and the economic impact the control procedures may have on the livestock industry. Many campaigns have proved ineffective because they concentrated on one procedure, such as vaccination, without the equally important control of livestock movement and disinfection of livestock facilities. The procedures used in a campaign to control a vesicular disease will depend on the status of the disease in the country when the control procedure is applied. Countries that were previously free of a disease approach the introduction of a new disease quite differently from those countries attempting control of an endemic disease.

The initial approach to vesicular disease control in a country previously free of the disease is the immediate quarantine and halting of livestock movement in the outbreak area, with destruction and disposal of all infected or exposed and susceptible stock. While this is a drastic procedure, it has proved successful in the past in several countries in preventing additional spread and has led to the eradication of the disease. Decontamination of infected premises by thorough washing and disinfection with appropriate compounds is necessary. Sentinel animals are then used to determine the adequacy of the decontamination procedure. Complete restocking can proceed when responsible officials are satisfied that the possibility of reinfection is eliminated. With diseases such as SVD where subclinical cases can occur, it may be necesasry to conduct serum surveys in the quarantine area to identify animals or herds that may have been infected but did not show clinical disease.

The development of vesicular disease control programmes in countries where the diseases are endemic must realistically evaluate the pertinent factors. For example, control of VS is severely handicapped by the lack of basic knowledge of its mode of transmission. If insect vectors play a role, then control of the vector is an important part of the programme. In the absence of such knowledge, the best hope in dealing with this type of disease is to develop methods such as vaccination which reduce the severity of the disease in the individual animal. Total elimination of a disease like VS where wildlife reservoirs and insect vectors may be involved is not a realistic goal. With FMD and SVD, however, eradication is feasible.

Vesicles on the snout 72 hours after start of FMD

Foot-and-mouth disease is usually given high priority and control methods are directed toward eradication because of the broad species activity of the disease and its impact on international trade. Far too often the programme is focused on vaccination rather than the equally important factors of control of livestock movement, disinfection and disease reporting. All programmes should be initiated on a small or pilot scale for two reasons: to gain experience in management and techniques, and to demonstrate to the agricultural community the feasibility and desirability of participating in programmes of larger scope.

Basic to the eradication of vesicular diseases are *strict quarantine, control of livestock movement,* and *elimination of pockets of infection by disposal of infected animals.* In all cases there must be thorough *washing and decontamination of infected livestock premises, vehicles and markets,* because a major factor in the spread of vesicular diseases is the movement of livestock through marketing channels. In those programmes where vaccines are used,

Sloughing foot epithelium seven days after start of FMD

the vaccines must be prepared from the appropriate virus types; they should be of the best quality, and safe for use in the species to be protected. The technology exists for the preparation of good FMD vaccines.

Eradication of vesicular diseases is a highly desirable objective but should only be attempted where all elements necessary for its success exist. These include acceptance of the programme by the livestock producers, sufficient financing for all elements of what could become expensive campaigns and, above all, realistic projection of the time the campaign will take to achieve its goal. Highly publicized programmes that promise more than can be delivered are more damaging than no campaign at all.

Vesicular exanthema of swine. A vescicular disease of swine indistinguishable from FMD, SVD and VS occurred in the United States prior to 1956, at which time it was declared eradicated. This disease, VES, was first described in California in 1932, where it remained until it spread in 1952 to 42 of the then 48 states; an extensive eradication campaign resulted in its elimination. This disease is of interest because recently it has been found that the virus is very similar to a virus that causes vesicular disease in certain marine mammals such as the California sea-lion. It has been suggested that the first cases in domestic swine in California may have been caused by feeding of meat from marine mammals or possibly fish. While VES no longer occurs as a disease of swine, it is important that surveillance for its possible re-emergence be maintained. Samples from a vesicular disease which cannot be identified as FMD, SVD or VS should be submitted to a laboratory equipped to diagnose VES.

Detailed descriptions of each of these diseases and the causative agents have been summarized in the literature by Dunne and Leman (1975). ■

Author's note: Mention of a trademark of a proprietary product does not constitute a guarantee or warranty of the product by the United States Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

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Current situation and outlook for animal feeds and animal products*

□ CEREALS

After the 1976 record world harvest, cereal production in 1977 is expected to decline marginally. However, with two consecutive good crops, the world cereal supply situation is satisfactory, and supplies are sufficient to meet global demand for food and feed and to maintain stocks at about 18 percent of annual consumption. Higher wheat and coarse grain stocks after the 1977 harvests contributed to declines in international grain prices between May 1976 and August 1977. Since then, prices have moved up by about 15 percent in response to increased demand.

Production. FAO forecasts *world cereal supplies* to remain adequate in 1977/78 even though wheat harvests in 1977 were smaller than expected earlier, and world stocks of wheat could decline slightly. World wheat and coarse grain production (1 108 million tons) is only 26 million tons below the large harvest of 1976.

Wheat output, of which only a small proportion is used as animal feed, declined in all regions. Production was 20 percent or more below 1976 in several of the large exporting countries, notably Argentina, Australia and Canada.

World coarse grain production for 1977 is now forecast at 723 million tons, a small increase from last year but still a record. Nearly all of the gain came from western Europe, the United States and Latin America, while output in the U.S.S.R. declined by over 10 percent.

Consumption of cereals as animal feed. The use of cereals as feed has fluctuated sharply during the past five years owing to changing availabilities and price levels. In developed countries a sharp decline in feeding in 1974/75 and a further fall in 1975/76 interrupted the continuous growth of the 1960s and early 1970s. Larger production and lower prices in the past two years have caused grain feeding to increase again. Further growth is expected in 1977/78, but feed use of cereals is likely to remain below the 1961-76 trend value for at least another year.

In the United States the 1977/78 feed use of grain is estimated to be 125 million tons, an increase of 9 percent over the previous year; wheat feeding is expected to increase by 3 to 6 million tons. More cattle are on feed, and pig and poultry numbers are also higher. However, even at this level feed use remains below the 1972/73 level of 147.5 million tons.

In the European Economic Community (EEC) wheat and coarse grain feeding expanded by about one million tons in 1976/77 and is expected to increase by a further 2 million tons during 1977/78, reaching a level of 70 million. Much of this increase reflects larger feed use of wheat which now accounts for an estimated 11.5 million tons. In recent years rising costs and the narrowing of profit margins appear to have contributed to an acceleration in the EEC in the use of non-cereal feeds, including cassava. In the U.S.S.R. feed grain consumption is again expected to expand in 1977/78.

There are a number of other countries where feed demand is growing rapidly because of the expansion of the livestock sectors and intensified feeding practices. Grain feeding has been increasing in Brazil and Turkey, supported by expanding domestic cereal production. In Greece, the Republic of Korea, Malaysia, Portugal and Spain the increased demand has led to higher feed grain imports.

Trade. The increase in cereal import requirements in the U.S.S.R. has been the most important recent development in world trade.

Reflecting recent changes, world imports of wheat and coarse grains are now forecast by FAO to rise to a record of 143.5 million tons, over 5 percent higher than last year, and also above the previous peak of 1975/76. The increase reflects mainly a rise in wheat imports.

Coarse grain imports in 1977/78 are expected to decline by 4 percent to 74 million tons from the high level of the previous year. A record barley crop and a recovery of maize production in the EEC, together with better pasture and larger availabilities of other feeds, have caused the decline in its import requirements from third countries. EEC imports are forecast to fall by 10 million tons from the exceptionally high level of 25 million tons of last year. Some increase in feed grain imports is anticipated for Greece, Portugal and Spain to satisfy expanding livestock sectors. In eastern Europe some decline is anticipated because of lower needs by the German Democratic Republic from the 1976/77 record. But regional imports of nearly 7 million tons would still represent the second highest coarse grain requirements ever. For the U.S.S.R., as production did not achieve its targets, a substantially higher volume of imports is forecast.

Elsewhere, Japanese imports will continue to expand, as livestock output increases, and some quantities may also be added to stocks. Feed imports into the Republic of Korea have risen sharply during recent years, and a further large increase is anticipated in 1977/78, as the domestic coarse grains harvest was poor. Malaysia and Iran continue to require larger feed imports in support of their livestock sector. In recent years, Iraq has also entered the import market on a continuing basis, and Egyptian coarse grain imports, which have increased annually for the past five years, will again expand.

Wheat and coarse grain stocks. Combined wheat and coarse grain stocks in the crop year ended 1977 were back to the 1972 "pre-crisis level". The greater part of this stock build-up was con-

* As of 15 November 1977
Source: FAO Commodities and Trade Division.

centrated in major exporting countries and in western Europe. Main exporters hold well over half of supplies, and the main importers about a quarter. In 1977/78 wheat stocks were expected to decline, while stocks of coarse grains are likely to increase mainly owing to larger stocks of coarse grains in the United States.

□ OILSEEDS, OILS AND MEALS

The early prospects of a significant increase in the production of the main oilseeds and oil crops in the 1977/78 season have been confirmed. Production of both edible/soap fats and oils and of oilcakes and meals (protein equivalent) in 1978 are now expected to show a large expansion over 1977 and to be well above the long-term trend values.

On the basis of information currently available, world oilseed and oil crops production is forecast to increase in all three economic regions, i.e., developed, developing and centrally planned countries; but the major expansion is expected in developed countries, primarily as a result of a substantially larger production forecast in the United States.

A record world production of *soybeans* is expected. This will mainly reflect prospects of a record crop in the United States, currently (November) officially forecast at 45.8 million tons or one third more than the unusually poor harvest last season and 9 percent above the previous record crop in 1973. The increase from last season is due to a combination of record high plantings (up by 18 percent) and record yields (up by 13 percent). In spite of a relatively low carry-over on 1 September of 2.8 million tons, U.S. soybean supply this season is estimated by the USDA at a new record of 48.6 million tons, 18 percent more than the level of the preceding season. With such levels of supply, the U.S. Department of Agriculture (USDA) expects both domestic and export demand to be significantly above last season's levels, though not sufficiently high to absorb all the supplies from the current crop; U.S. carry-over stocks of soybeans on 1 September 1978 are thus currently expected to increase to around 6.8 million tons, the highest level since 1 September 1969. In Brazil, where the crop will be harvested around next April/May, current indications are for a moderate increase in soybean output. A continuing expansion in production is also expected in Argentina, Mexico and Paraguay.

World output of *cottonseed* is expected to increase, largely as a result of a 25 percent increase forecast in U.S. production but also of increases in a number of other countries. World *groundnut* production is anticipated to increase, mainly owing to a recovery in the Indian crop. In contrast, the U.S. crop is now forecast some 4 percent below last season's, reflecting the somewhat lower area harvested and yields per hectare, while production in Africa is also likely to show some reduction. There are prospects of substantially larger supplies of *sunflower seed* following a recovery in the U.S.S.R. crop after two consecutive poor harvests and larger plantings in Argentina and the United States. World output of *rapeseed* is expected to recover from its relatively low level of the preceding season. The Canadian crop is currently forecast at over 80 percent above the previous season's level; however, as opening stocks this season are sharply reduced from a year ago, total Canadian supplies could remain somewhat smaller than last year.

Among tree crops, a modest recovery in *olive oil* output is anticipated from last season's level, with increases mainly in Italy and Tunisia expected to more than offset reduced output in some other countries, particularly Turkey. *Copra* output is currently forecast at around the 1977 level. A further expansion, likely to be more pronounced than in 1977, is anticipated in world *palm oil* production, primarily in Malaysia, where practically all the increase will be available for export. With regard to the major animal fats, some increases are forecast, reflecting larger slaughterings. Fishing prospects for 1978 cannot be ascertained at this stage, but the fish catch in Peru may recover only moderately from the 1977 sharply reduced levels: the Peruvian authorities, who suspended anchovy fishing last May, have subsequently decided not to resume fishing until the second half of 1978.

World production of *oilmeal protein* in 1978 is expected to grow even more strikingly than edible/soap fats and oils, reflecting the predominant share of soybeans (with a high protein content in comparison with other oilseed crops) in the overall expansion of oilseed crops, as described above. The current forecast of production is of an all-time record of 36.8 million tons (protein equivalent), or 5.9 million tons (19 percent) more than in 1977 and 2.0 million tons above the 1965-76 long-term trend. Here again, however, beginning stocks, particularly of U.S. soybeans, are considerably smaller than a year earlier, so that the increase in total available supplies will be less than that from current production. Requirements for consumption in the traditional major consuming countries are likely to be sizably larger than in 1977, encouraged by favourable livestock/feed price relationships.

The prospect of abundant supplies of oil-meal proteins in 1977/78 has been the main cause for the rapid decline in international market prices of these products in the second half of 1977, (although in recent weeks the price fall has tended to level off). This reflected in part short-term factors but also a renewed consumer interest in meals at the relatively low prices now prevailing. With the relatively ample world supplies this coming season, prices of most major oilseeds and oilseed products should be expected in coming months to be somewhat below their levels of the corresponding period last season.

□ MEAT

The rise in world meat production has slowed down this year; while the production of pig and poultry meat will reach new record levels, that of bovine and sheep meat will decline. Total output of the four main meats is estimated to reach about 123 million tons in 1977, or 2.5 percent more than last year. Output in 1977 has recovered sharply in the U.S.S.R., among the major producers. It has continued to grow fast in Japan, but production has grown at a very moderate pace in the United States and the EEC. In Oceania, output has changed little. Meat production of developing countries has increased by only 1.5 percent to 22 million tons, less than a fifth of world production. The slow growth in the developing regions partly reflects the levelling off of Argentina's production.

In part owing to the slow economic growth and in part to higher domestic market prices in a number of important consuming countries, demand for meat in developed countries has remained rather slack. Although consumption of poultry and pigmeat has increased, that of beef and veal has fallen. There has been a faster increase in demand in centrally planned and developing countries. None-

theless, because of higher domestic supplies, import demand of eastern Europe and the U.S.S.R. has slowed down in the second half of the year. Purchases by the richer developing countries have continued to grow and imports into the United States, the world's largest meat importer, have recovered from their setback during the first half of 1977; imports into the EEC have remained relatively low. Total world trade in meat is expected moderately to exceed last year's volume. In value terms, the increase could be somewhat more pronounced since prices in international trade have also risen, especially for mutton and lamb, and to a lesser extent for beef. Prices in international beef trade, however, are still below those registered in the early 1970s.

The outlook is for the current rather slow growth of world meat output to continue in 1978. Beef production will probably decline further. However, there are indications that in some major countries in the northern hemisphere the cyclical downswing in cattle inventories may come to an end. The present favourable feed situation could encourage farmers further to expand their breeding herds as well as to retain animals for more intensive fattening. Sheep flocks appear to be expanding again in the exporting countries in the southern hemisphere, reflecting the improved profitability of sheep meat and wool production vis-à-vis beef and milk production. Pigmeat output is expected to grow rather slowly in the first half of next year in some major developed countries, with the major exception of Japan, but the present favourable relationship between feed and pig prices could result in a significant expansion in 1978/79. The effects of the favourable feed situation on poultry production have been more immediate.

If demand were to continue by and large at 1977 trends, the implications for trade would be: import demand of centrally planned countries might slow down further with the decline in their 1977 grain crops made up by larger imports of feeds rather than livestock products; beef imports into the United States could rise; Japan, the second largest meat importer, might curb its imports further, as domestic poultry and pigmeat output continues to rise rapidly; and in the EEC, the current high level of stocks and some additional output as a result of the dairy cow reduction programme would probably continue to limit imports, at least during the first half of next year.

Imports of beef, sheep and poultry meat to the richer developing countries may expand. In recent years, their imports of meat have grown at an even faster pace than those of dairy products. Imports of meat and live animals in 1977 into the petroleum-exporting developing countries and some other countries indirectly benefiting by the higher oil export revenues, notably Egypt, are estimated to reach over 600 000 tons of carcass meat equivalent, five times more than before the oil price boom and over 10 percent of world meat imports (excluding intra-EEC trade). Iran, Saudi Arabia, Iraq, Kuwait and Libya are also important buyers in this group of countries and more recently, Nigeria and Venezuela have also become substantial importers.

However, the richer developing countries have not only expanded their purchases of livestock products but, in their efforts to develop their own livestock industries, they have also imported growing quantities of breeding stock, feed and other inputs, equipment for processing and marketing, as well as technical expertise. In the longer run this could result in a slowdown in their purchases of livestock products.

☐ MILK AND MILK PRODUCTS

The rise in world milk production has accelerated further this year, and total 1977 output is now estimated to reach about 445 million tons, or almost 3 percent more than in 1976. A major contributing factor to this growth has been the rapid recovery of production in the U.S.S.R. In the United States and Japan output has also grown rather fast, whereas there has been little change in the output of the export-oriented dairy industries in Australasia. Production in Europe will probably exceed last year's level by about 2 percent. In the developing regions, where the rise in output has again been most pronounced in Latin America, growth rates have averaged between 2 and 3 percent.

The outlook is for the current relatively fast rise in world milk output to continue during the first half of 1978, though there could be a slowdown in 1978/79. Present dairy cow numbers in the main dairying areas are at about last year's level, with a decrease in inventories in developed countries being offset by an expansion in centrally planned countries. As winter fodder supplies, especially in Europe, are larger and concentrate feeds cheaper than in 1976/77, yields could increase.

Demand for milk and milk products is also expected to expand, particularly in the centrally planned countries and in developing countries. However, because of the larger domestic supplies, eastern Europe and the U.S.S.R. are expected not only to reduce substantially their imports but also to export more dairy products than in 1976/77. By contrast, imports of the developing countries (notably OPEC members) are likely to grow further. Since the early 1970s dairy products imports of the petroleum-exporting developing countries have more than doubled to reach approximately 3 million tons of milk equivalent in 1977. This will be almost half of total commercial imports of developing countries or a sixth of world dairy imports (excluding intra-EEC trade).

In the developed countries demand for milk and milk products as a whole will probably remain slack. There should be a further increase in the demand for cheese and fermented milk products, but demand for liquid milk will at best level off, while that for butter could decrease further in a large number of countries. Notwithstanding a rise in sales to the developing countries, the excess of output of developed countries over commercial outlets can therefore be expected to grow further. The imbalance will be increasingly concentrated in the EEC and the United States. Whereas Canada, Australia and some smaller countries in western Europe have recently curbed milk output and reduced stocks of dairy products, the current dairy cow reduction programme in the EEC is not expected to improve significantly the disequilibrium. The decrease in dairy cow numbers, at present estimated at half a million, or 2 percent of the Community's dairy herd, will be offset by higher yields while domestic commercial demand for milk and milk products is still tending to fall.

In view of the continuing oversupply situation in the developed countries and some increase in export supplies of centrally planned countries, prices in international dairy trade will remain depressed. Current international prices of skim milk powder and butter, at U.S.$450 and U.S.$1 050 per ton respectively, although somewhat higher than last year, are still less than a third of the level of domestic market prices prevailing in developed countries in the northern hemisphere. ■

Course on the management and breeding of cattle

This course is designed to give those involved with cattle production, development and research an insight into current thinking and a forum for in-depth discussion of technical developments. Particular attention will be focused on the potential contribution of current research and development to commercial practice in cattle production.

The course is being organized by the Edinburgh School of Agriculture in cooperation with the Animal Breeding Research Organization, under the sponsorship of the British Council, from 7 to 20 May 1978. The Director of Studies will be Dr. J.H.D. Prescott, Head of Animal Production Development in the Edinburgh School of Agriculture. The course will be centred on the campus at West Mains Road, Edinburgh. Visits to the Rowett Research Institute and to the School of Agriculture, Aberdeen, will form an integral part of the course.

Lecturers from the Grassland Research Institute, Hill Farming Research Organization, the Meat and Livestock Commission, the West of Scotland College of Agriculture and the Universities of Newcastle and Nottingham will participate in the programme. The course will comprise lectures in which new techniques and thinking on genetic improvement, reproduction, nutrition, feeding systems, growth and carcass quality and livestock management will be introduced and discussed in study group sessions. This part of the programme will be integrated with visits to laboratories, field research centres and farms. Lecturers and course tutors will participate in all aspects of the programme.

Preparatory information, including relevant review articles, will be provided for participants before the course. The fee for the course, which will be wholly residential, is £365. Course members will be accommodated in a hotel in Edinburgh. Applications for the course should be made to the British Council or related institutions.

International courses in pig and poultry husbandry

The eighth series of international courses in pig and poultry husbandry will be held at Barneveld College, the Netherlands, from 13 September 1978 to 16 March 1979. They are primarily intended for students from developing countries who perform teaching or advisory functions in pig or poultry husbandry and related fields. The courses will be conducted in English and will take students to a post-diploma level. The coverage includes theoretical studies, demonstrations, excursions, practical work and writing reports.

Details regarding admission requirements, fees, accommodation and the two syllabuses can be obtained from: The Director, Barneveld College, P.O. Box 64, Barneveld, the Netherlands.

Postgraduate course in Animal Science

The eighth in the series of postgraduate courses in Animal Science organized under the FAO/DANIDA[1] Cooperative Programme will be conducted at the Royal Veterinary and Agricultural University, Copenhagen, Denmark, from 1 September 1978 to 30 June 1979. The principal object of the course is to provide advanced training in the breeding, nutrition and management of cattle to animal husbandry teachers and research workers from the developing countries. A Diploma of Animal Science award may be made by the University to candidates who successfully complete the course.

Participants in the course are selected from among candidates nominated by governments at the invitation of FAO. Admission requirements include a degree from a university or other institute of higher education equivalent to at least the B.Sc. (Agric.) or B.V.Sc. The candidates should have an adequate knowledge of English to benefit from the course.

The course, which combines lectures and practicals as well as a research project, is administered by the Veterinary Faculty for FAO Fellows at the Royal Veterinary and Agricultural University. The Director of the course is Professor A. Neimann-Sørensen, Head of the Department of Cattle Research.

Further information may be obtained from Dr. N-I. Heje, Coordinator, Secretary to the Veterinary Faculty for FAO Fellows, Bülowsvej 13, DK-1870 Copenhagen V, Denmark.

[1] Danish International Development Agency.

10th World Congress of Buiatrics

The 10th World Congress of Buiatrics, organized by the Mexican Association of Bovine Practitioners, will be held in the Congress Unit of the Medical Centre in Mexico City, Mexico, from 16 to 19 August 1978.

The principal focus of the congress will be on reproduction, problems of dairy cattle production, mastitis, and the improvement of milk and beef production in the tropics.

New ILCA Director

D.J. Pratt, Head of the Project Objectives Branch of the Land Resources Division of the Ministry of Overseas Development of Great Britain, has been appointed Director of the International Livestock Centre for Africa (ILCA) as from January 1978.

Mr. Pratt was a member of the task force that was commissioned to examine the need for internationally sponsored research on livestock in Africa, which resulted in the creation of ILCA. He has been a member of ILCA's Board of Trustees and its Programme Committee since their inception. He has extensive experience in livestock development and in the management of forage and range resources in Africa.

FAO/ILCA/UNEP study on trypanotolerant livestock

Following a meeting at FAO, Rome, in April 1977, a joint study on trypanotolerant stock has been initiated by FAO, the International Livestock Centre for Africa (ILCA), and the United Nations Environment Programme (UNEP). The basic aims of this joint study are to survey the present status of the trypanotolerant livestock of west and central Africa; appraise existing data and information on their productivity; and present comparisons between trypanotolerant and non-trypanotolerant livestock maintained under comparable conditions.

This will allow plans to be prepared for conservation and use of trypanotolerant cattle breeds in danger of absorption or extinction; for encouragement of the most effective use of trypanotolerant breeds and crosses in livestock development schemes in the humid and semi-humid tropics; and for further research on trypanotolerant animals and trypanotolerance.

Work on trypanotolerant cattle breeds in danger of absorption or extinction will be focused primarily on the west African Shorthorn breeds and crosses (including Muturu, Race des Lagunes, Somba, Baoulé, Borgou, Biu, Ghana Shorthorn, Bakosi and Manjaca). Cattle productivity studies will be concerned with these breeds plus the N'Dama, together with any non-tolerant breeds maintained alongside trypanotolerant animals. Productivity studies on other trypanotolerant livestock will be mainly directed to sheep and goats, but any available information on pigs will be included.

During this joint study preliminary inquiries will be made with government sta-

tions and institutions, universities, commercial ranches, village groups, etc., having suitable facilities and programme intentions, concerning their possible willingness to cooperate in further work on the use and the potential of trypanotolerant livestock.

Following the joint FAO/ILCA/UNEP study, further work will be undertaken by FAO and ILCA to encourage the most effective use of trypanotolerant breeds and crosses. This will be concerned with research (mainly ILCA) and development programmes (mainly FAO).

Further research could be done on the comparative performance of trypanotolerant and non-trypanotolerant livestock in the production of meat, milk and draught power to make possible an evaluation of the biological, economic and social consequences of their use in various environments.

For development schemes, in view of the interest in establishing and expanding multiplier herds for trypanotolerant breeds, further work could be concerned with the definition of breeding goals, the laying down of selection strategies for their achievement and the elaboration of possible plans for the utilization of the increased numbers of animals.

In all cases the aim will be to support, supplement and cooperate with existing national and regional research stations and programmes and to work in close collaboration with other international organizations operating in this field. ■

NEW BOOKS

Cheese and fermented milk foods

By Frank V. Kosikowski. Published by Edwards Brothers, Inc., Ann Arbor, Michigan. Second edition, 1977. 711 pages, 346 figures, 109 tables. Price: U.S.$35.00.

This is the revised and expanded edition of a book which was very well received when it was first published ten years ago. The author intends to use his new book in part in his courses "Food Processing Fermentation" and "Food Processing Demonstrations" at the Department of Food Science, New York State College of Agriculture and Life Science, Cornell University, Ithaca, New York, U.S.A.

The structure and form of the new edition have been influenced by the author's travels, his living in countries outside the United States, and by his courses on "International Food Science and Development" and "High Protein Food Technology," also conducted at Cornell University.

The 27 early chapters have been revised, expanded and rearranged, and ten new chapters and more than 100 new illustrations and tables have been added. Emphasis has been placed on yoghurt, standards, nutrition, public health and safety, imitation cheeses and on new cheese-making methods in developed and developing countries. References are included at the end of each of the 37 chapters.

The book will be very valuable for industry, universities and technical schools, public health officials and consumers in developed and developing countries.

F.W.

Veterinary epidemiology and economic research

R.J. Esslemont and P.R. Ellis, University of Reading, Department of Agriculture and Horticulture, Study No. 21. The Melbred Dairy Herd Health Recording Scheme. A report on the economic, reproductive and husbandry changes in 22 herds over three seasons. Price: £2.00.

The Veterinary Epidemiology and Economics Research Unit in the Department of Agriculture and Horticulture, University of Reading, was created in order to foster interdisciplinary cooperation in the field of animal health. Under the leadership of Mr. P.R. Ellis, the team is currently made up of four veterinarians, two economists, an agricultural scientist, an animal production specialist, a computer programmer and appropriate ancillary staff. It also enjoys extensive part-time help from various other institutions and a strong link has been forged with a number of veterinary practices.

The primary aim of the Unit is to develop epidemiological techniques and information systems which contribute to a fuller understanding of the multifactorial character of animal health problems, with particular regard to farm livestock and human health. Linked to this are the exploration and adaptation of techniques of economic analysis which can be used to determine the value of prevention and control measures on the farm as well as in organized programmes.

The study of the Melbred Dairy Herd Health Recording Scheme gives a detailed description of the data collection system applied and presents a complete analysis of the reproductive efficiency of the dairy herds in the scheme, as well as a discussion of the economic implications of changes in fertility indices. The study is an excellent example of the fruitfulness of the multidisciplinary approach adopted by the Unit.

C.A.H.

Kenya beef records

Published jointly by the Ministry of Agriculture, Kenya, and the International Livestock Centre for Africa. 3 parts. August 1977. Unpriced.

This set of three handbooks reports on a cooperative operation carried out by the Ministry of Agriculture, Kenya, and the International Livestock Centre for Africa. The aim was to strengthen the Kenya Beef Records of the Kenya Government Livestock Recording Centre, thus allowing it significantly to expand its operations.

Part 1, the field handbook, covers the background to the value of a beef recording scheme in Kenya; the information that must be collected to allow biotechnical improvement; and the provision of detailed guidelines governing the collection, analysis and use of relevant data. Part 2, the data preparation handbook, deals with all aspects of data preparation for the system and any data alterations required as a result of output messages. Part 3, the computer operation handbook, encompasses the complete operation of the system.

This is a valuable set of handbooks to promote the use of performance testing as an aid to the genetic improvement of beef cattle. Although the virtues of performance testing have gained wider recognition and accep-

tance in developing countries in recent years, there has been inadequate demonstration of how, in practice, performance testing programmes can be implemented. These handbooks can serve to bridge this gap.

P.M.

Animal Regulation Studies

Published by the Elsevier Scientific Publishing Company, P.O. Box 330, Amsterdam, the Netherlands. Subscription price for Vol. I in 4 issues (1977): U.S. $47.75 (Dfl. 117), including postage.

Animal Regulation Studies is a multidisciplinary journal sponsored by the World Federation for the Protection of Animals. It aims to report on advanced work in animal control and welfare.

The Editor-in-Chief of the journal is Dr. W. Ross Cockrill. He states in his editorial in Vol. I, No. 1, that the use of animals for the benefit of man involves much abuse and that the contents of this journal will be devoted to all aspects of the science of animal regulation with the objectives of increasing knowledge, reviewing problems, moderating abuses and influencing attitudes and the formulation of regulations in the entire field of animal control and welfare.

The first issue of the journal contains five main articles: euthanasia of dogs and cats; problems relating to animal capture; art and animal welfare; animal welfare legislation in Europe; and why people own pets.

P.M.

Il Vitello ("The Calf")

Dialma Balasini. Edagricole, P.O. Box 2202, 40139 Bologna, Italy. 1977. 76 pages, 177 illustrations. In Italian. Price: 7 000 lire.

This publication is designed to provide the farmer with information on modern methods of selection and rearing of calves for meat production. It deals *inter alia* with the physiology of gestation and management of the cow before and after parturition, health problems encountered among calves just after birth and during the first weeks of weaning, and the feeding and management of calves destined for the meat market, or for reproduction. Consideration is given to both small feed units and large feedlots; illustrations are provided of installations, fittings, premises and specialized farms.

Marketing problems and trends are also discussed. Live animal and carcass evaluation, price formation and analysis of returns are demonstrated. These should all be of real interest to farmers.

G.M.B.

Animal nutrition and feeding practices in India

By S.K. Ranjhan. I.V.R.I., Izatnagar (U.P.), India. Vikas Publishing House PVT Ltd, New Delhi. 1977. 339 pages, numerous figures and tables; no references. Price: Rs. 40.

In the preface the author states that this book is primarily meant for undergraduate students studying in veterinary and agricultural colleges in India. In the light of this, it is surprising that it is completely bereft of references.

The first part of the book is devoted to the principles of animal nutrition, while the second part deals with applied animal nutrition. The techniques of feed evaluation (digestibility, intake) are discussed and the common fodders available in India described. Particular attention is given to the characteristics and processing of by-products and unconventional roughages that can be utilized in animal diets. The third part reviews briefly various feeding standards and the nutritional requirements of different classes of livestock. In the fourth and final part the author is concerned with feeding practices in cattle, buffaloes, sheep, goats, pigs and poultry. Examples are given of how rations are calculated; a limited amount of information is also provided on the economics of different feeding practices in the light of recent data obtained experimentally in India.

M.C.

Sausage-products technology

Endel Karmas, Food Technology Review No. 39. Noyes Data Corporation, Park Ridge, N.J. 07656, United States. 1977. 317 pages, numerous figures and examples; indices for companies, inventors and U.S. patent numbers. Price: U.S.$39.00.

The book is based on U.S. patents issued since the early 1960s and covers the fields of sausage-products technology which the U.S. patents dealt with during that period of time. It presents an advanced, descriptive, technically oriented review of sausage making as depicted in U.S. patents.

The book is divided into two parts: emulsion ingredients, and production methods. The first part includes various emulsion additives from the viewpoint of cure colour and flavour (development and stabilization, prevention of rancid flavour, fermented flavour) and emulsion stability (texturing agents, chemical stabilizers). The last two chapters of this part deal with some methods for recovering useful proteinaceous material from meats and meat by-products to be used as sausage ingredients (defatting methods, recovery from bones) and with product control methods (composition control, product and ingredient identification).

The second part deals with sausage processing, such as emulsion formation and preparation (also apparatus and non-meat protein supplement), stuffing, linking, cooking and casing removal as well as the production of miscellaneous conventional and novel sausage products.

It has to be stressed that, although the book is not intended to cover all fields of sausage-products technology, some topics are described very widely and deeply, including the scientific basis and the measures of practical use. As the book supplies technical information and can be used as a guide to the U.S. patent literature, it will be of interest to those dealing with scientific, practical or development aspects of sausage-products technology and technique.

S.C.

Animal Reproduction Science

Published by Elsevier Scientific Publishing Company, P.O. Box 330, Amsterdam, the Netherlands. Subscription price for Volume I (in 4 issues), 1977: U.S.$56.95 (Dfl. 142.00) including postage.

Animal Reproduction Science is a new journal devoted to the publication of scientific papers dealing with the study of reproduction in animals that are of use to man. The journal aims at bridging the gap between fundamental scientific research and the management aspects of reproduction. The areas that fall within the scope of the journal are:

- oestrus cycle research in domesticated animals
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- artificial control of reproduction
- preservation of gametes and embryos
- disease as a factor influencing reproductive performance

- diagnostic and therapeutic techniques in animal production
- laboratory tests for pregnancy diagnosis
- nutrition and pregnancy
- foetal characteristics; embryonic mortality; parturition losses; significance of birth weight; early post-natal mortality
- sterility; intersexuality
- animal reproduction in tropical and underdeveloped countries
- control of vertebrate animal pests.

The Editor-in-Chief of the journal is Dr. T.J. Robinson, Head of the Department of Animal Husbandry, University of Sydney, Sydney, N.S.W. 2006, Australia.

P.M.

Monograph on Patanwadi sheep of Gujarat

By P.O. DAVE. Directorate of Animal Husbandry, Gujarat State, Ahmedabad. Printed by Government Press, Baroda, India. First edition, 1977. 65 pages. (In English)

Apart from its local interest to breeders of Patanwadi sheep in Gujarat, this book has two important lessons for those concerned with animal breeding in all parts of the world. Firstly, it is an example of a thorough study of a local animal genetic resource and, secondly, it analyses, summarizes and makes generally available records which have been collected over many years.

The current interest in animal genetic resources too often takes the form of a fascination with the high performance of exotic breeds and an attempt to improve the local breed by importation and crossbreeding. This is often a mistake because the imported breed is not adapted to local climatic, feeding and management conditions; this applies especially to sheep and goats. Gujarat has a population of 1.7 million sheep, of which nearly 1 million belong to the Patanwadi breed producing the world-renowned Joria wool. Here this valuable resource is fully described: environment, history and characters of the breed, performance. The figures are obtained from the records accumulated by the sheep breeding farms, research stations and extension centres, and the wool laboratory and grading centres of the Department of Animal Husbandry, Gujarat State.

From the results, conclusions are drawn on how to improve production by attention to management (e.g., test rams for fertility before use, restrict breeding to optimal season, turn over ewes rapidly) and by genetic selection. There is rightly no suggestion of importation and crossbreeding; this is a highly productive breed well adapted to local conditions.

I.L.M.

Livestock Feeds and Feeding

By D.C. CHURCH. Distributed by O & B Books, Corvallis, Oregon, U.S.A., 1977. 349 pages, numerous tables, figures and references. Cloth cover. U.S.$ 16.00. (In English)

After the "Basic Animal Nutrition and Feeding" by D.C. Church and W.G. Pond (1974) and the three volumes of "Digestive Physiology and Nutrition of Ruminants" (Vol. 1, Digestive Physiology, 2nd ed., 1975, by D.C. Church; Vol. 2, Nutrition, 1971, by D.C. Church *et al.*; Vol. 3, Practical Nutrition, 1972, by D.C. Church *et al.*), this book intends to give detailed information on the more applied topic of classification, composition and technology of feedstuffs, ration formulation and practical feeding of the various classes of domestic animals.

This book starts with an introduction of 42 pages giving some fundamental principles on nutrition. It also deals with aspects of feed additives and with the laws and regulations governing feed sales. The second part is devoted to feedstuffs for animals. The characteristics, composition, and nutritive value of the various classes of feedstuffs, including by-products and unconventional feed resources, are reviewed. Feed preparation, feeding standards and aspects affecting feed consumption are also mentioned, and one chapter deals with the principles and techniques of ration formulation with some practical examples. The third and final part is devoted to the principles and the practice of feeding the various categories and classes of livestock. Tables of feed composition and NRC tables on nutrient requirements are presented in the annexes.

This book, like the previous ones, will serve to guide students in animal nutrition and professionals who have to face any practical problem in animal feeding.

M.C.

Improving the nutritional efficiency of beef production

Edited by J.G. TAYLOR and J.M. WILKINSON. The Commission of the European Communities, Directorate-General for Scientific and Technical Information and Information Management, European Centre, Kirchberg, Luxembourg ,1976. 402 pages, numerous tables and figures. Price: U.S.$ 10.00. (In English)

This publication contains the proceedings of one of the seven seminars held during 1975/76 under the auspices of the EEC * Commission with the Community's programme of research on beef production. It was organized in October 1975 by the INRA Centre de recherches zootechniques et vétérinaires, Theix, France. The subject was high on the priority list of research objectives drawn up in 1973 by members of the Standing Committee on Agricultural Research. The objectives of the seminar were to review current feeding practices and recent results of research on improving the nutritional efficiency of beef production; to achieve a better understanding of nutritional factors influencing growth and development of beef cattle; to consider the practical application of research results; and to assess the requirements for future research in this field.

The meeting was attended by 36 representatives of universities and research institutes chiefly from EEC member countries. The 27 invited papers that were presented are published in six parts, each of which ends with discussion of the papers within the section. The introductory part describes current beef cattle feeding practices in the EEC member countries. Parts II to V deal with means to improve the economic efficiency of beef nutrition. Efficiency is thus considered in relation to land resources and physiological animal potential. It therefore includes: choice of crops for maximum animal output per unit of crop area and methods of minimizing inputs of energy in feed production; nutritional properties of crops and effects of their processing on efficiency of utilization by animals; use of crop residues and agro-industrial by-products; and optimizing economics in systems for the production of beef cattle with a high growth potential. Part VI gives an indication of future research needs with particular reference to choice of crops, nutritional characteristics of crops and methods for improving their efficiency of utilization, and economic aspects of beef production systems.

The book provides a comprehensive summary of up-to-date information on nutritional aspects of beef production in the EEC.

L.M.

* EEC = European Economic Community.

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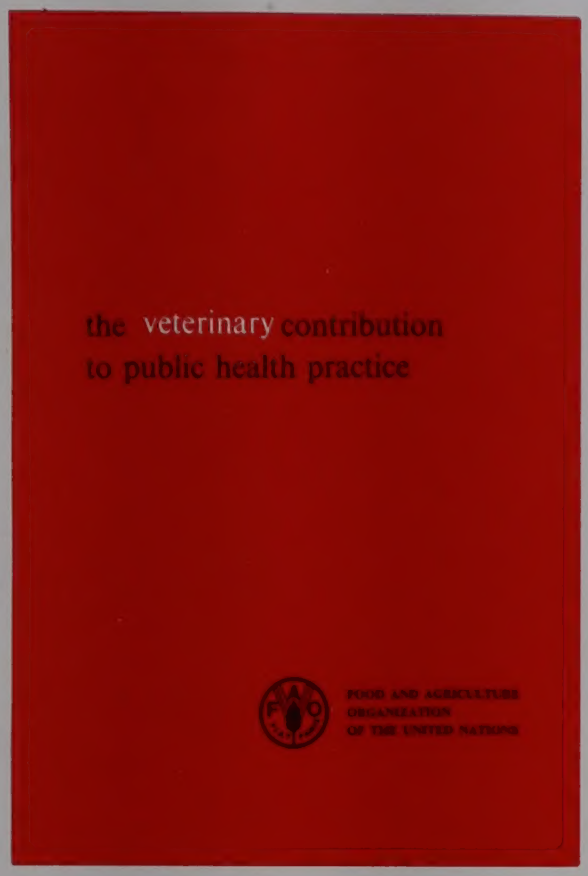

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